

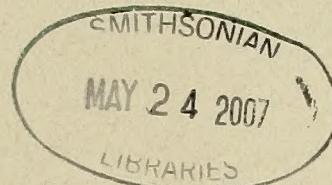
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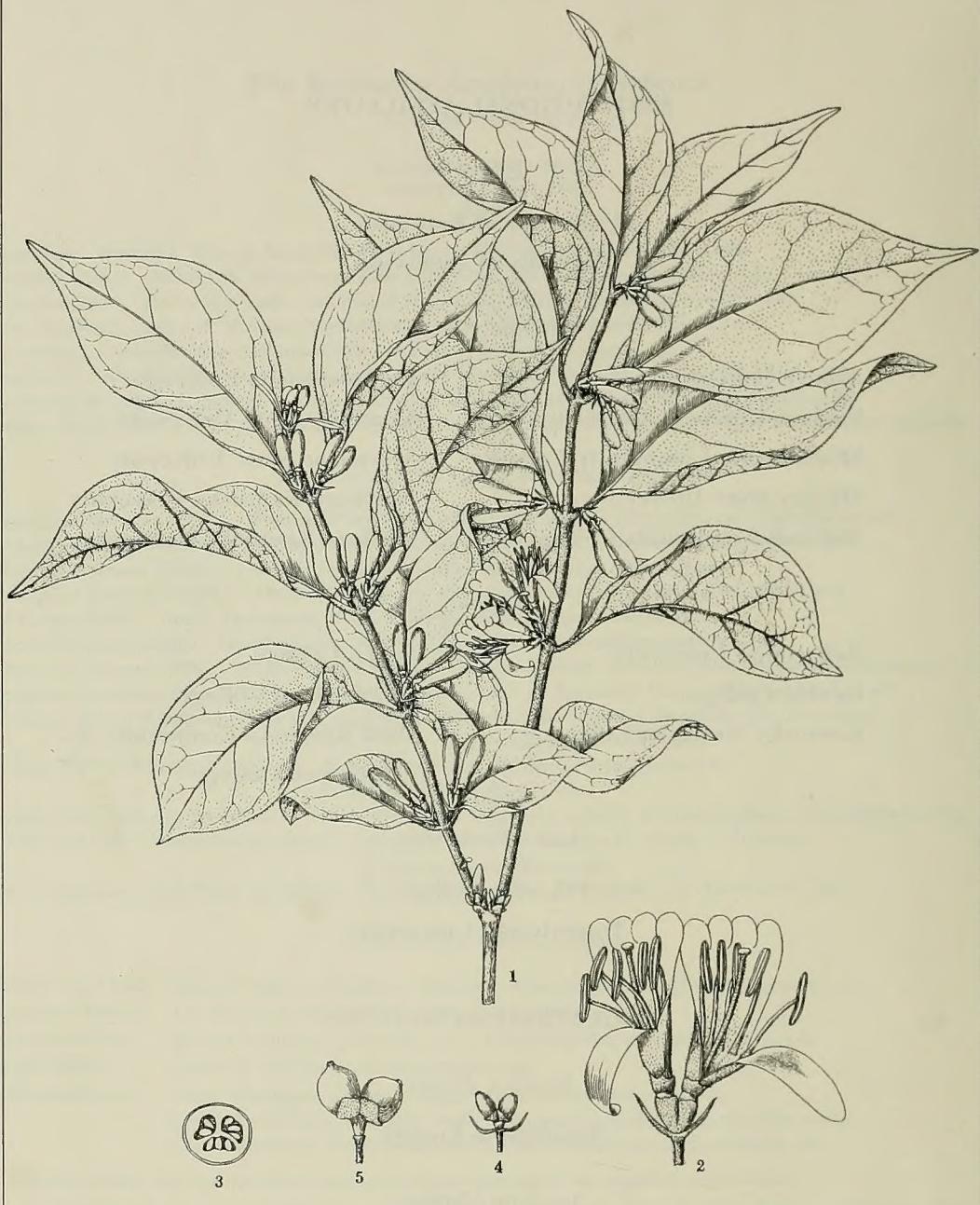


Figure 1. Amur honeysuckle (*Lonicera maackii*). 1. Flowering branch. 2. Pair of flowers. 3. Cross-section of ovary. 4. Pair of young fruits. 5. Pair of mature fruits. From Hoa, K.-S. Caprifoliaceae. Fascicle 3 in T.-N. Liou. *Flore illustrée du nord de la Chine*. 1934. See article starting on page 97.

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The Invasion of Amur Honeysuckle (*Lonicera maackii*; Caprifoliaceae): A Chronicle of Questions

James O. Luken

Department of Biology, Coastal Carolina University, P.O. Box 261954, Conway, South Carolina 29528

ABSTRACT

The invasion of Amur honeysuckle (*Lonicera maackii*) into North America is now well studied. The chronicle of published research for this invasion reveals a shift in the types of questions scientists ask when a plant species is introduced and it emerges as an invader. Initial questions focused on traits of the species; later questions focused on community-level interactions. Future questions regarding invasive species will likely address the match between traits of invaders and traits of invaded habitats.

INTRODUCTION

Soon after I arrived at Northern Kentucky University in 1984, John Thieret gave me a tour of his favorite plant-collecting sites. As we prowled the railroad yards, roadsides, and fourth-growth woodlots of the northern Kentucky landscape, one shrub species was ubiquitous. I didn't recognize it and when I showed him a branch of the shrub, his reply was "Horrible species—don't pay any attention to it." We continued our hike, but the mystery shrub persisted; I had to ignore a plant that barred us from entering some forest patches. Finally, John gave in to my interest and he delivered a short speech on Amur honeysuckle (*Lonicera maackii*; Caprifoliaceae; Figure 1) and its invasion of the northern Kentucky/Greater Cincinnati area.

During the last 40 years, Amur honeysuckle attracted the attention of many botanists and ecologists. The chronicle of published research on the species is lengthy; through time it reveals a shift in the types of scientific questions that are asked when a plant species is introduced and eventually becomes a dominant member of local plant communities (i.e., when it invades). The purpose of this paper is to trace

how ecological understanding emerged for a relatively local invasion. Lessons learned from studying Amur honeysuckle may indeed provide a road map for framing future research efforts in invasion ecology.

THE INTRODUCTION PHASE

Amur honeysuckle has a long and complex history of introduction. Luken and Thieret (1995) documented the various mechanisms and pathways that were involved in getting Amur honeysuckle from its native habitat in Asia to the New World. There were multiple introductions beginning in 1896, and numerous informal experiments were conducted primarily at botanical gardens and arboreta. Although these garden experiments were done to screen for desirable horticultural traits, other types of information were obtained. For example, as early as 1924, it was noted that Amur honeysuckle tended to spread by seeds from the point of planting (Luken and Thieret 1995).

It is not well understood why there were multiple introductions of the species. Perhaps there was the hope that unique and more useful varieties could be found. Variation among the different introduced genotypes was, how-

ever, small relative to the variation of individual plants in response to different environmental conditions (Luken et al. 1997b). This trait in Amur honeysuckle (i.e., high plasticity) and other traits (e.g., weediness) contributed to its banishment from gardens; the same traits, however, suited it well for invasion of disturbed landscapes.

THE ESCAPE PHASE

Amur honeysuckle moved from the garden to the wild. This was first noted in Ontario Pringle (1973) and in Cincinnati, Ohio, by Braun (1961). Dispersal was likely facilitated by birds (Ingold and Craycraft 1983). The dates of these publications are useful in that they indicate at least the beginnings of an invasion. However, given the introduction record of Amur honeysuckle it is likely that escape to the wild (i.e., beyond the garden) occurred much earlier. Such escapes are difficult to observe and are usually dependent on the local activity of a botanist who constantly notes the changing flora.

There are many important questions that could have been asked during the escape phase of Amur honeysuckle. Do plants spread or jump from the point of initial introduction? How does the size of the initial introduction affect the speed of invasion? What types of habitats are invaded first? Why does Amur honeysuckle invade in only a small part of the larger introduced range? These questions must now be addressed in areas where the shrub has not yet invaded.

THE DOMINANCE PHASE

Amur honeysuckle emerged as a dominant member of forests and open sites in urban and agricultural landscapes. Initial research focused on biomass and production (Luken 1988); later research focused on growth and physiological ecology of the species (Deering and Vankat 1999; Luken et al. 1995, 1997b). In the late 1980s, there was an untested theory that invasive species possessed unique characteristics that allowed them to enter and dominate plant communities. However, with Amur honeysuckle as with many other invaders, the traits that confer success in the wild are diverse and often assume utility only when habitats have been altered by human activity. Individual plants of Amur honeysuckle respond quickly to in-

creased light availability (Luken et al. 1997b) and seedling establishment occurs across a wide range of light conditions (Luken and Goessling 1995). Forest edges, areas with low canopy cover, and forests close to seed sources are most heavily invaded (Hutchinson and Vankat 1997; Medley 1997).

Most of the research focused on the dominance of Amur honeysuckle alluded to community-level impacts of the species (i.e., changed species composition, reduced richness, modified successional processes). Dominance was assumed to represent displacement of other species, and suggestions were made for shrub removal (Luken and Mattimiro 1991). However, community-level impacts are difficult to demonstrate and the "displacement assumption" is a risky one in human-modified landscapes where invasive species colonize disturbed soils. But the final phase of Amur honeysuckle research addressed the question of community-level impacts.

THE INTERACTION PHASE

Amur honeysuckle had community-level impacts. Removal experiments with Amur honeysuckle showed that growth of annual species (Gould and Gorchov 2000), and tree seedlings (Gorchov and Trisel 2002) was negatively affected by the presence of the shrub. Shrub removal also facilitated emergence of other species from the seed bank. (Luken et al. 1997a). The results of these experiments were relatively predictable considering what we know about light limitation in the forest understory. However, questions still remain regarding long-term community development. For example, the ability of Amur honeysuckle to change forest development will depend on maximum longevity of individual shrubs and seedling recruitment as shrubs die. Comparison of plants in northern Kentucky to plants in the native habitat in China suggests that introduced shrubs achieve greater size and age (Luken pers. obs.). While it is tempting to assume that Amur honeysuckle may lead to a novel and relatively stable invaded state of various types of plant communities, the future holds new invaders and new disturbances that might change this forecast.

IN RETROSPECT

The picture of the Amur honeysuckle invasion is far from complete, but it is still a

relatively good picture. Several factors contributed. There were numerous colleges and universities located in northern Kentucky and southern Ohio, an area heavily invaded by the shrub. This provided a steady stream of biologists and biology students willing to study the invasion. There were large numbers of invaded sites, thus providing high sample sizes. The plants were easy to identify, count, age, and grow. And, most importantly, invasion ecology emerged as a fashionable sub-discipline at about the same time that Amur honeysuckle emerged as a dominant species. (It is perhaps ironic to note that most of the ecologists involved in local Amur honeysuckle research were trained to pursue ecological questions focused on far-away places like the slopes of mountains, tropical forests, or tundra.) Clearly, the Amur honeysuckle invasion fostered better ecological understanding of a highly disturbed landscape. And now we know that relevant and fundable ecological questions can be addressed outside the boundaries of old-growth forests and formally designated nature preserves.

Scientific understanding forms the basis of environmental management. This raises the question of whether or not Amur honeysuckle should be controlled. Many values have been expressed regarding this issue (Luken 1994) and I can't contribute much that is new. However, I do know that when well-intentioned people march into the woods and begin pulling, cutting, or spraying dominant plants, the goal and the end result are often very different. Thus before the weeding begins, it's important to ask and then perhaps answer some hard questions about the management goals for plant communities and the possibility of achieving these goals in human-dominated landscapes.

And finally, many questions still remain about the Amur honeysuckle invasion. How have the large fruit and seed crops produced by Amur honeysuckle affected animal populations? What are the cell and molecular mechanisms that allow such strong physiological and phenotypic plasticity relative to light? How might vacant niches in the understory contribute to invasion susceptibility of forests? These questions and others will likely be addressed soon with the conclusion that suc-

cessful invasions require the right plant in the right habitat.

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Geoarchaeological Investigations at the Whitfield Site (15HL21): A Buried, Multicomponent Habitation Site in Southeastern Kentucky

Richard L. Josephs

P.O. Box 8358, Department of Geology and Geological Engineering, University of North Dakota, Grand Forks, North Dakota 58202

ABSTRACT

The Whitfield site (15HL21), a buried, multicomponent, prehistoric habitation site along the Cumberland River in Harlan County, Kentucky, was the subject of an archaeological and geoarchaeological investigation. The geoarchaeological phase focused on the alluvial sediments comprising the first terrace (T-1). A sequence of overbank levee deposits was found to contain artifacts dating to the Late Archaic and Woodland cultural periods (ca. 6000 to 1500 B.P.). Backhoe trenches, test units, and soil borings were used to examine the Holocene geomorphic evolution of the site and its subsequent effects on the archaeological deposits contained therein. A combination of stratigraphic relationships, proveniences of temporally diagnostic artifacts, and numeric dating techniques was used to establish a chronological framework within which both natural and cultural site formation processes could be interpreted. The geoarchaeological evidence suggests that a mid-Holocene period of renewed aggradation, the result of increased storm frequency and intensity affecting the southeastern United States, was responsible for burying the majority of the archaeological component.

INTRODUCTION

The section of the Cumberland River flowing through southeastern Kentucky follows a narrow, deeply entrenched, meandering valley that forms some of the most rugged terrain in the Commonwealth (Childress 1992; McGrain and Currens 1978). Little is known about the alluvial stratigraphy along this relatively remote stretch of the river. In terms of archaeological knowledge, this area of Kentucky remains virtually terra incognita. Previous investigators have suggested that systematic deep testing along the floodplains of the upper Cumberland River would contribute significantly to our understanding of this area's prehistoric development, both from an archaeological and a geological standpoint (Autry and others 1988). This article discusses: (1) a site-specific geoarchaeological investigation of the Holocene paleoenvironment within the upper Cumberland River basin; and (2) the dynamic relationship that existed between the region's earliest human inhabitants and the physical settings they chose to occupy.

The Whitfield site (15HL21), located 4 km west of the city of Harlan, Kentucky, along the banks of the Cumberland River (Figure 1), was identified during reconnaissance level archaeological investigations conducted in November 1987 at the request of the U.S. Army Corps of Engineers. The site is located on land

designated for construction of an artificial levee, part of an extensive series of flood control measures ongoing throughout the valley. Site 15HL21 was initially described as containing buried cultural deposits dating to the Late Archaic period, ca. 6000 to 3000 B.P. A single backhoe trench, excavated within overbank levee deposits, encountered stone tools, clusters of fire-cracked rock, and associated lithic debitage at a depth of 50 to 75 cm below the existing ground surface (Autry and others 1988). Further testing revealed a series of relatively low intensity occupations spanning the (late) Middle or Late Archaic through Late Woodland periods, roughly 5500 to 1200 B.P. (Pace 1995). These dates were based upon conventional ¹⁴C analysis of wood charcoal as well as on the vertical distribution of temporally diagnostic lithic and ceramic artifacts. On the basis of its archaeological integrity, the decision was made to mitigate the site employing a multidisciplinary approach.

PHYSICAL SETTING

The Whitfield site is located on a first terrace (T-1) ca. 10 m above the normal level of the Cumberland River (Figure 2). The cultural components are buried by overbank levee deposits. The backside of the levee slopes gently away from the crest; the riverward side forms a steep scarp descending ca. 5 m to the surface of the active floodplain (T-0). The sta-

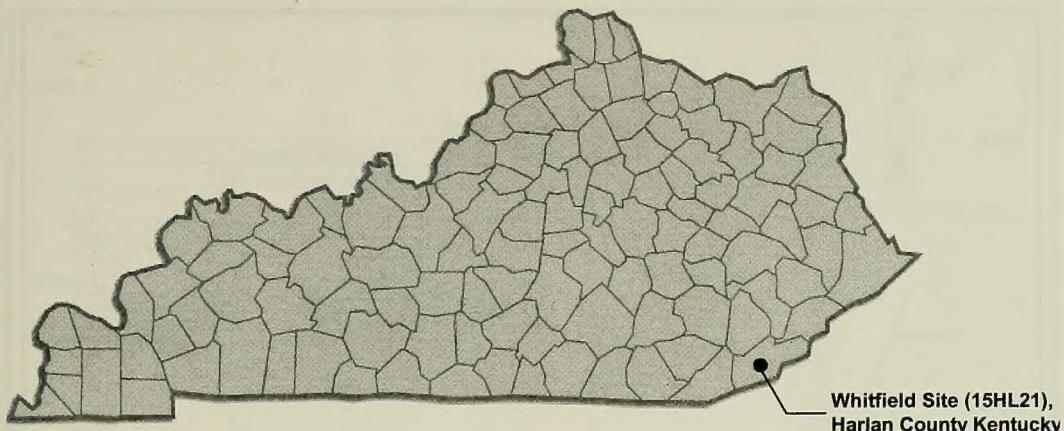


Figure 1. Location of the Whitfield site (15HL21), Harlan County, Kentucky (base map from GraphicMaps.com 2003).

bility of the river's straight channel pattern in the immediate vicinity of the Whitfield site, as well as the steepness of the terrace scarps, is directly related to its position along the base of a steep, northwest-southeast trending ridge

(Figure 3). The bedrock bluffline directly across (southwest) from the site has virtually halted channel migration/lateral accretion in that direction (Josephs 1997).

The formation of the first terrace (T-1) cor-

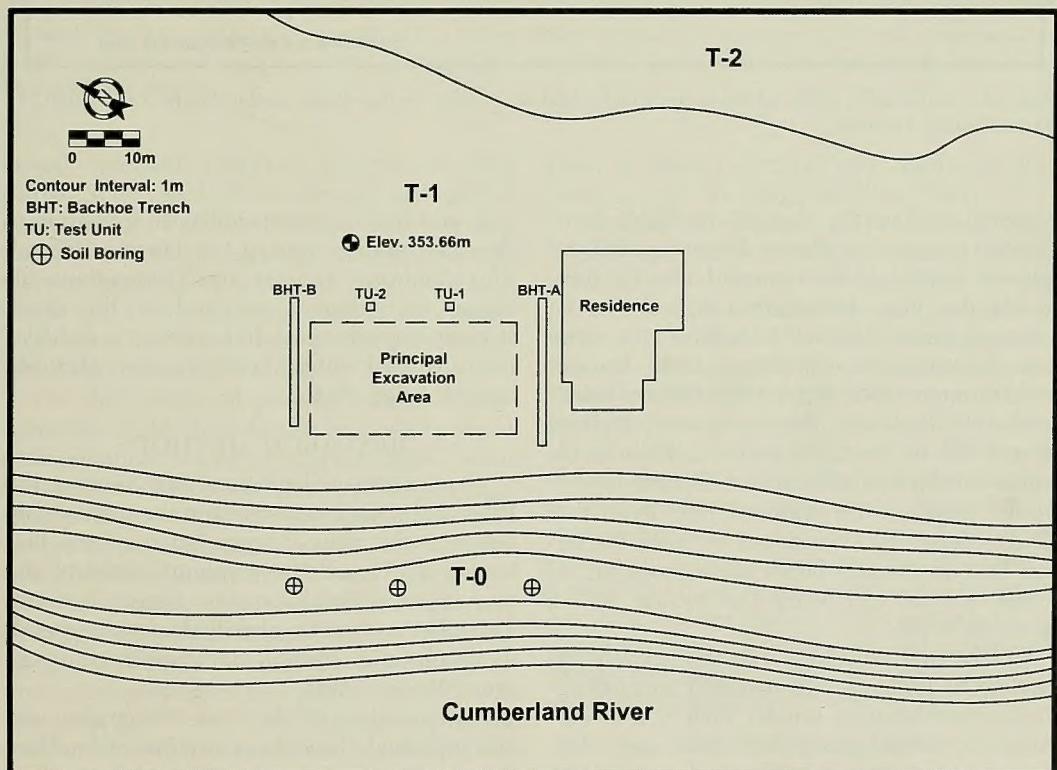


Figure 2. Topographic map of the Whitfield site (15HL21), Harlan County, Kentucky, showing terrace locations and areas of archaeological and geoarchaeological testing.

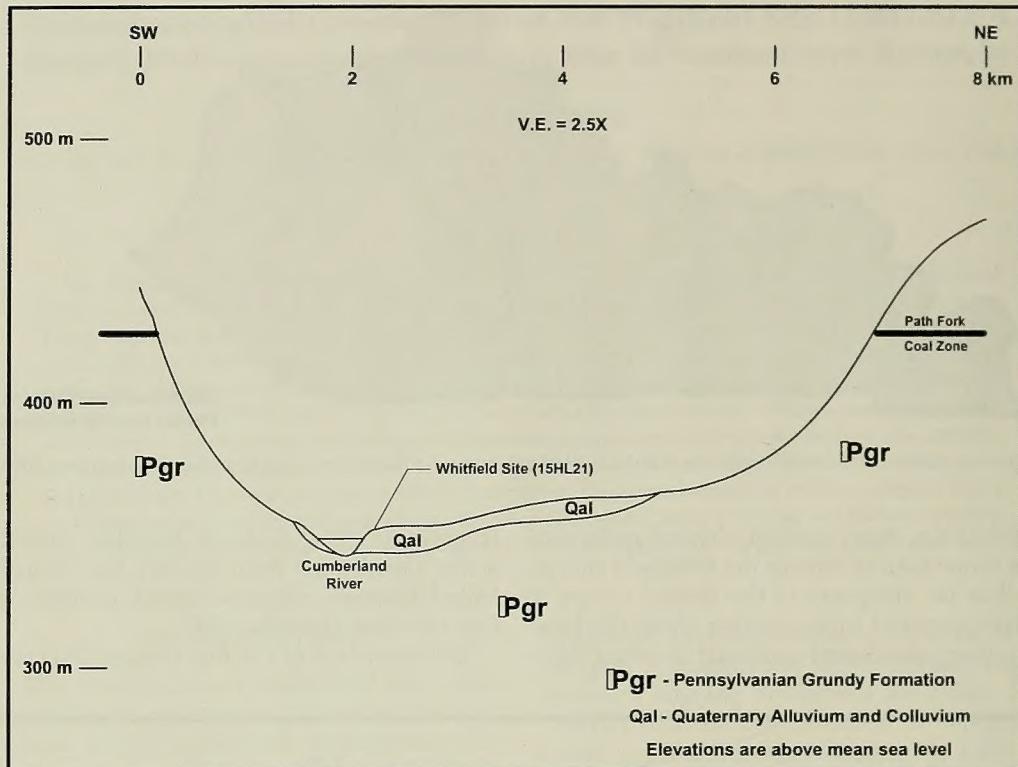


Figure 3. Cross-valley profile of the upper Cumberland River valley in the vicinity of the Whitfield site (15HL21), Harlan County, Kentucky.

responds well with a channel-overbank depositional scenario: a classic fining-upward sequence in which finer-grained alluvial sediments (i.e., the top-stratum facies) overlie coarser-grained alluvial sediments (i.e., the bottom stratum facies) (Boggs 1995; Daniels and Hammer 1992; Ritter 1986; Waters 1992). At the Whitfield site, the top-stratum deposits of very fine to fine sandy loams and sandy clay loams overlie bottom-stratum deposits of culturally sterile, well-stratified fine to coarse sands (Figure 4). The contact between the top and bottom stratum facies occurs over an interval of 2 to 3 m below the surface of T-1 (Josephs 1997).

Soil borings advanced into the actively aggrading floodplain (T-0) revealed an unstratified accumulation of greater than 3 m of medium to coarse loamy sand and sand. The presence of twig and leaf mats (representing former, short-lived flood plain surfaces [Bettis 1994]), dispersed historic artifacts, industrial

slag, and coal fragments indicates formation of this land surface during the Historic Period. This landform reflects the tremendous increase in sediment supplied to the area's streams over the past 100 years as a result of intensive coal and timber extraction (McBride and McBride 1996).

RESEARCH METHODS

The geoarchaeological investigations at the Whitfield site were focused on the relationship between the alluvial aggradation of the first terrace (T-1) and the resultant burial of the prehistoric cultural remains. Research at site 15HL21 can best be classified as a site-specific, diachronic, alluvial landscape reconstruction (Waters 1992).

Interpretation of the site's stratigraphy was accomplished through excavation of backhoe trenches, test units, and soil borings as well as inspection of riverbank exposures. Descriptions of all soil profiles and core samples fol-

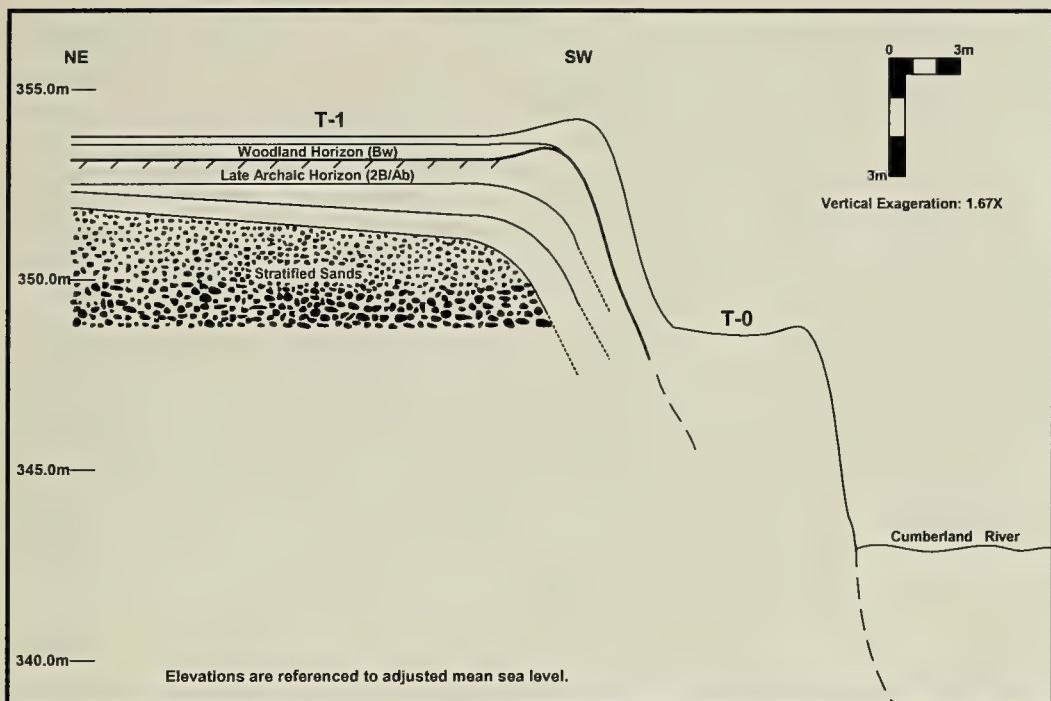


Figure 4. Profile of the Whitfield site (15HL21), Harlan County, Kentucky, depicting soil development, the boundary between vertically and laterally accreted sediments (top and bottom stratum facies), and their association with the buried cultural deposits.

lowed standard U.S.D.A. procedures (Soil Survey Staff 1993). The horizontal and vertical components of all the backhoe trenches, test units, soil borings, and soil sample locations were referenced to a vertical datum (benchmark) and Cartesian coordinate system established over the site as part of the archaeological investigations (Pace 1995).

The distribution of particle sizes in a sediment can yield clues to the four elements of sedimentation: source, transport agent, environment of deposition, and postdepositional changes (Stein 1985). Particle-size analysis was concentrated on the sand (coarse) fraction (particles between 2 and 0.0625 mm) which provides interpretive evidence for lithologic and pedologic discontinuities and degree of weathering and depositional regimes based on morphological properties and particle distribution (Timpson and Foss 1993). The sand fraction was subdivided into three size classes by wet sieving: coarse sand (2–0.5 mm), medium sand (0.5–0.25 mm), and fine sand (0.25–0.0625 mm) (Wentworth 1922). The silt- and clay-size

fractions were evaluated as a combined, fine fraction, unit (Timpson and Foss 1993).

Samples of feature fill collected from hearths and middens were submitted for dating by the Oxidizable Carbon Ratio (OCR) procedure. This is a relatively new dating technique that analyzes the biochemical degradation of humic materials and charcoal and quantifies its degree of alteration as a ratio of total carbon to readily oxidizable carbon (Frink 1992, 1994a, 1994b). The OCR procedure provided an independent verification of the conventional radiocarbon estimates that were secured from the previous phase of archaeological investigations (Josephs 2002). Conjointly, these dates would serve to establish time frames within which periods of alluvial landscape development and prehistoric human occupation could be more accurately assigned (Brakenridge 1984; Ferring 1986).

SITE STRATIGRAPHY

Alluvial Stratigraphy

A sequence of valley-fill sediments comprises the first terrace (T-1) at the Whitfield site

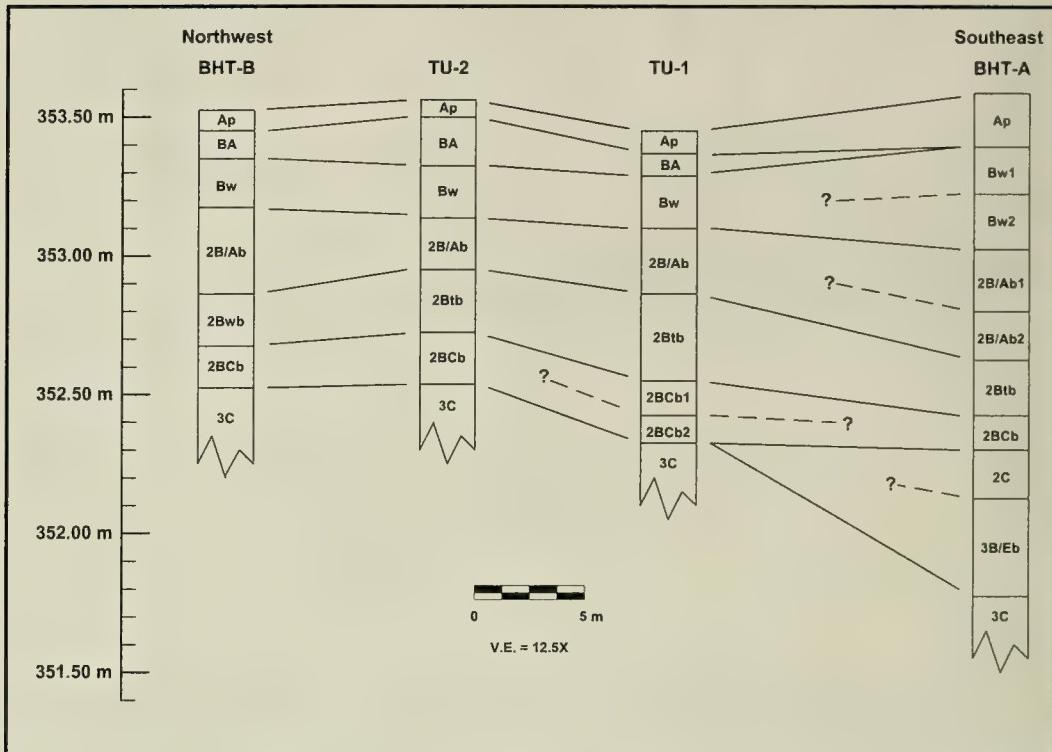


Figure 5. Soil columns, paralleling the Cumberland River northwest to southeast), showing pedostratigraphic relationships across the Whitfield site (15HL21), Harlan County, Kentucky.

(Figure 4). In all profiles, the uppermost 33 to 56 cm consists of fine sandy loam deposited during the late Holocene (Foss 1996; Josephs 1997). The evidence for prehistoric occupation was confined to the top-stratum facies of the T-1 (Figure 4). These upper strata include a mechanically disturbed topsoil (Ap), underlain by a weakly-developed, cambic (Bw) horizon (Figure 5). The Ap horizon contains organic debris in various states of decomposition along with fragments of coal, slag, and road metal. Therefore, this surface horizon exhibits no potential for containing in situ prehistoric artifacts. The underlying Bw horizon contains the site's Woodland component (ca. 3000 to 1000 B.P.) (Josephs 1997). Temporally diagnostic grit-tempered pottery sherds and small, triangular projectile points/knives were recovered from this stratum (Pace 1995).

Of primary importance to this study is the interpretation of a buried, transitional 2B/Ab horizon containing the Late Archaic component (ca. 6000 to 3000 B.P.) with the majority

of the site's artifacts and cultural features (Figures 4 and 5). This fine sandy loam paleosol is present in the subsurface across the T-1 and is characterized by a distinct color change (darker colored horizon) that occurs between 33 and 56 cm below the existing ground surface (Figure 5). The unconformable contact between the top of the 2B/Ab and the base of the overlying Bw horizon represents a period of landscape stability followed at some later point by renewed overbank deposition. The transitional B/A designation is assigned to this horizon due to the mixing of cumulative and non-cumulative soils by various physical, chemical, and biochemical processes (Josephs 1997).

The 2B/Ab horizon can be further subdivided into as many as three distinct intrastrata representing discrete episodes of surface exposure (diastems) followed by rapid burial during floods. Weak horizonation displayed within the 2B/Ab soil suggests that each of these former surface horizons remained at the

floodplain surface for only short periods of time and were consequently exposed to a very limited amount of subaerial weathering (Bettis 1994). Sadler (1981) contended that, in most stratigraphic sequences, more time is represented by the diastems than by sediments deposited between them. The large concentration of relatively fine particle sizes, coupled with no significant evidence of postdepositional disturbance of the archaeological deposits, indicates burial by quiescent, suspended load (overbank) deposition. Bettis (1994) surmised that similar top-stratum facies at the Main Site (15BL35), 25 km downstream from the Whitfield Site, were deposited under relatively low energy, non-erosive conditions during floods that favored relatively rapid burial of the archaeological deposits with little in the way of disturbance by fluvial processes prior to burial.

Chronostratigraphy

Samples of organically enriched feature fill obtained from the lowest levels of the 2B/Ab horizon, ca. 85 cm below the surface, produced an OCR date of 5525 ± 170 B.P. (ACT#2477) (Figure 6). This compares well with a radiocarbon date of 5260 ± 60 B.P. (Beta-81076) from a sample of wood charcoal obtained from the lower portion of the 2B/Ab, ca. 80 cm below surface. A second sample of feature fill recovered from the upper portion of the 2B/Ab, at a depth of about 60 cm, produced an OCR date of 3839 ± 120 B.P. (ACT#2476). Each of these three dates falls securely within the Late Archaic and brackets the development of the 2B/Ab horizon between roughly 6000 and 3000 years before present. These dates agree well with the temporally diagnostic projectile points/knives recovered from this horizon (Josephs 1997).

A third OCR sample retrieved from the upper half of the overlying Bw horizon, ca. 25 cm below ground surface, produced a date of 2390 ± 70 B.P. (ACT#2474), which falls within the Early Woodland Period. A sample of wood charcoal recovered from the lower half of the Bw horizon, roughly 8 cm below the OCR sample, produced a radiocarbon date of 2490 ± 80 B.P. (Beta-81075), also within the Early Woodland Period. Once again, these dates are consistent with age ranges typically assigned to the cultural artifacts found within the horizon and confirm a 3000-year time

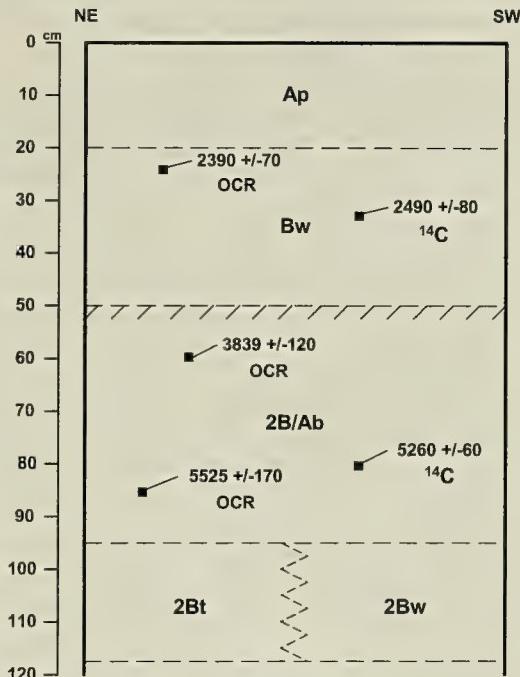


Figure 6. Chronostratigraphic soil profile illustrating the comparison between the OCR dates and the ^{14}C dates obtained at the Whitfield site (15HL21), Harlan County, Kentucky.

frame for the cumulative and non-cumulative development of the buried paleosol (Josephs 1997).

PROXY PALEOCLIMATE EVIDENCE FOR CUMBERLAND VALLEY AGGRADATION

Evidence for increased precipitation, and a concomitant renewal in fluvial activity in the southeastern United States at the beginning of the late Holocene, can be found in the marine (Balsam 1981), pollen (Delcourt 1979), and vertebrate (Klippel and Parmalee 1982a, 1982b) records. The marine record produces some of the clearest paleoclimatic signals. Sea-surface temperatures, derived from planktonic foraminifera in western North Atlantic cores, reached their postglacial zenith by 6000 B.P. (Balsam 1981). This period of ocean warming produced a significant increase in the frequency and intensity of summer storms, resulting in increased precipitation across the southeastern United States during the mid- to late-Holocene (Delcourt 1985; Wendland 1977).

Brakenridge (1984) found evidence for increased fluvial activity and overbank accretion along the Duck River in central Tennessee between 6000 and 4000 B.P. He attributed these conditions to an interval of more meridional (south-north) upper atmospheric circulation resulting in an increase in storm frequency and severity. Such an increase in meridional atmospheric circulation causes the Arctic Air-mass to penetrate farther southward during winter, while the Maritime Tropical Airmass expands northward during summer, resulting in an increase in the number and intensity of storms across eastern North America (Delcourt 1985). The increased frequency of meridional circulation patterns after 6000 B.P. is significant because the associated slow moving storm systems often generate persistent heavy rains followed by large floods (Knox 1983). At the Whitfield site, the buried paleosol containing the Late Archaic component appears to have aggraded during this same period (Josephs 1997).

DISCUSSION

Extreme southeastern Kentucky has yet to undergo the level of professional archaeological investigation that permits probative conclusions regarding subsistence strategies, material culture, and settlement patterning. The upper Cumberland River basin would have been an ideal setting for the exploitation of riparian and upland resources. The floodplains and terraces would have provided an environment suitable for settlement and agriculture. The river and uplands would have furnished valuable floral, faunal, and lithic resources.

In this particular area, both colluvial and alluvial processes can act to bury archaeological sites on floodplains and terraces bordered by narrow river channels on one side and steeply sloped uplands on the other. The region's bedrock lithology and structure, particularly the presence of shale and coal interbeds, enhance slope instability and promote mass wasting. As mentioned previously, local timber and mining concerns have greatly exacerbated erosion over the last century.

Due to their relatively undisturbed contexts, buried archaeological horizons hold the greatest potential for containing significant amounts of the natural and cultural prehistoric information to be found in such geomorphic set-

tings. Relatively rapid sedimentation protects the deposits from erosion and weathering and contributes to the accumulation and preservation of paleoecological (ecofacts) and cultural (artifacts) remains. It is hoped that the information presented here will provide valuable, albeit limited, insights into prehistoric human ecology in the upper Cumberland River Valley and serve as a guide to future interdisciplinary studies conducted in the region.

CONCLUSIONS

The alluvial sediments at the Whitfield site contained the artifactual remains of two distinct prehistoric cultures. A combination of stratigraphic relationships, temporally diagnostic artifacts, and numeric dating techniques provided a chronological framework within which both physical and cultural processes could be interpreted. The accumulation/formation of the entire top-stratum facies occurred over a time span of roughly 6000 years. The proveniences of temporally diagnostic remains of Late Archaic and Woodland cultures support the OCR and radiocarbon chronology of alluvial landscape development in this part of the upper Cumberland River valley. The results of these investigations yielded the following conclusions:

- (1) Evidence of prehistoric occupation was restricted to buried contexts within the top stratum facies along the first terrace (T-1);
- (2) Aggradation of the top stratum facies occurred as the result of suspended-load deposition under relatively low energy, non-erosive flooding conditions during the middle and late Holocene;
- (3) Alternating periods of landscape stability followed by increased floodplain sedimentation appear to reflect regional paleoclimatic trends;
- (4) Lateral accretion/channel migration is severely constrained by a bedrock bluffline directly opposite the Whitfield site; and
- (5) The actively aggrading floodplain (T-0) formed within the Historic past and, therefore, exhibits no potential for containing in situ prehistoric artifacts.

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Manslick Road Cemetery, Burial 34, Louisville, Kentucky

Susan D. Spencer

Program of Archaeology, University of Louisville, Louisville, Kentucky 40292

ABSTRACT

An unmarked grave in Manslick Road Cemetery, Louisville, Kentucky, Burial 34, was excavated during a 2001 University of Louisville Field School. The grave contained numerous adult, infant, and fetal bones in an excellent state of preservation. Most adult bones consisted of extremities and exhibited signs of sawing, knife cuts, and drill holes. Some infant long bones had small perforations created by a needle-like object. The modification to specific elements was indicative of the medical practices of amputation, preparation of mounted medical school skeletons, and dissections. The grave contained a minimum number of individuals (MNI) of 16. In addition, there is evidence of a structural fire, based on the presence of charred bone and ash and burnt wood, hardware cloth, and plaster. Test-tube glass and a glass medicine bottle were among the material culture found. Artifact analysis and historical records suggest these materials were in a medical school fire between 1907 and 1910.

INTRODUCTION

Manslick Road Cemetery, owned by the City of Louisville, Kentucky, is located in Jefferson County northeast of the intersection of Interstate 265 and Manslick Road. In the 19th century, ca. 12 acres were purchased to bury the dead from the City Work House (later the Home for the Aged). The cemetery also may have been used for patients who died in the City of Louisville Eruptive Hospital (Anonymous 1913). Archaeological data and historical documents demonstrate that burials took place from the mid 19th century to the late 20th century. City of Louisville burial records, dating from the 1940s, indicate some burials as late as 1982 (Bolin 1998).

A tentative plan for construction of an access ramp, Interstate 265 (Watterson Expressway) to Manslick Road, is currently under consideration. Because of the potential impact to the cemetery, the University of Louisville conducted an archaeological field school to determine the number and density of graves that might be affected.

LOCATION OF BURIAL 34

Archaeological testing consisted of a series of trenches across the cemetery. A metric x, y, z coordinate system was established from a datum point in the central part of the cemetery. In a trench excavated along the E0 line, starting at S98 to S30 meters, a block excavation was laid out (S63 E0, S59 E0, S59 E3, and S63 E3). An outline of a grave shaft was encountered within this unit. The number 34

was assigned to the grave to be excavated. A monument marking an adjacent grave reads, "E.L. Rhodes / 1875–1904."

EXCAVATION METHODS AND PROCEDURES

Excavation of Burial 34 began on 2 Aug 2001. The outline of the grave shaft was found by using a backhoe, and then the grave shaft was hand excavated. The grave was oriented east to west, traditional in Christian burials. The top of the casket was found 110 cm below the surface. The casket was rectangular, 200 cm east to west and 50 cm north to south.

Hand excavations continued with extreme care beginning at the east end, typically where the feet of the decedent would be encountered when the remains are in anatomical position. However, at a depth of 110 cm, in the center of the casket, the proximal end of a tibia was exposed in association with a rib, the first indication that the remains were not in anatomical position.

Continued hand excavation revealed that the elements were heaped along the south wall in the center of the casket. A fragmented os coxa was against the west end, and nothing was against the east end. On the southeast side were numerous artifacts such as hardware cloth, medicine bottle, buttons, broken handmade light bulb, and brass grommets from shoes. The southwest side contained a red substance that covered the bones and surrounding matrix, which consisted of ash, plaster fragments, burned wood, and sandy-loam

soil. The sandy-loam soil of the grave site allowed water to drain away from the casket, creating excellent preservation.

The elements were sorted into separate bags at the site to aid in separating and identifying individuals. The grave yielded numerous complete hands and feet of adults and complete infant and fetal skeletons in anatomical position. This suggests that the hands, feet, and skeletons were articulated when placed in the casket. The remaining adult elements were not in anatomical position, indicating that they were disarticulated prior to placement.

A sample of the red substance was taken. The Munsell soil color chart indicated the color to be red, 10R4/8 (Anonymous 1977). The substance was found predominantly on the elements articulated at time of burial, such as the infant and fetal remains and the complete adult hands and feet. Therefore, it is suggested that it is a mold, a preserving agent, or an "injection mass that was impregnated with red lead" in order to take X-ray pictures (Kanavel 1912).

The next day, excavation continued. No casket handles were found. The final depth of the excavation was 152 cm. The grave was back-filled by the backhoe. The contents of Burial 34 were reburied in January 2002.*

SUMMARY OF GRAVE CONTENTS

At the laboratory, the remains were sorted onto trays, washed, and dried. There were 2 trays of fetal and infant remains, 2 trays of ribs, a tray of lower long bones, a tray of upper long bones, a tray of elements of the feet, a tray of elements of the hands, a tray of cranial fragments, 4 trays of unidentified bone fragments, and 2 trays of artifacts.

By using FileMaker Pro 4.0, Professor DiBlasi and I created a database used for sorting the remains. Each element was numbered. Then the following characteristics for each element were used to sort the remains: age, sex and race, modifications, pathology, side, burned or unburned, and whether the red substance was present.

Minimum Number of Individuals (MNI)

In estimating the MNI in Burial 34, complete and fragmented elements were used. This is assuming that the proximal fragments did not have corresponding distal fragments.

When possible, remains of the same individual were matched (by age and sex) and noted.

For this analysis, a sub-adult is an individual under the age of 23, an estimation based on the lack of epiphyseal unions of specific elements. This includes fetuses, infants, and children. The minimum number of sub-adults, based on the number of right scapulae, is 10. An adult is an individual of age 23 or older, an estimation based on the epiphyseal union of specific elements. The number of adults based on the number of left calcanea is six. Therefore, the total minimum number of individuals in Burial 34 is 16.

Element Modifications: Amputations

There is evidence that human remains found in Burial 34 are from a medical school: the presence and location of saw and knife marks, indicative of the practice of amputations, preparation of "mounted" medical skeletons, and dissection. Several infant and fetal elements exhibited perforations by a needle-like object, suggesting they were "pinned down" for dissection.

The evidence of amputations is based upon the presence of saw and knife cut marks distributed among specific elements. The location of these cuts and their location on specific elements were compared to a mid-19th century medical manual (Ludlow 1867). Ludlow described amputations for the thigh, calf, foot, arm, forearm, and hand. It was found that the elements and the locations of the cuts were almost identical to the location and methods described by Ludlow. Examples found among the remains in Burial 34 include the following: Amputations of the thigh occur at midshaft of the femur (Figure 1) (Ludlow 1867:381, Figure 239). Burial 34 contained one example of a femur partially sawn at midshaft and then broken. Amputations of the calf are performed 2 to 3 inches below the tubercle of the head of the tibia (Figure 2) (Ludlow 1867:386, Figures 247, 248). Two tibiae and 1 fibula fit these criteria. One tibia consisted of only a midshaft; proximal and distal ends were sawn off. The proximal end of the other tibia was sawn through. The fibula was partially cut with a knife above midshaft and then broken.

Amputations of the foot can occur at the junction of the tarsal and metatarsals or of the calcaneus and cuboid bones (Figure 3) (Lud-

Figure 1: Amputations of the Thigh**Figure 2: Amputations of the Calf****Figure 3: Amputations of the Foot****Figure 4: Amputations of the Upper Arm****Figure 5: Amputations of the Forearm**

low 1867:388, Figure 249). One calcaneus was sawn through, and 1 talus was partially cut with a knife. However, Vitali et al. (1978:128) suggested that amputations of the foot can occur just proximal to the metatarsal heads. Thirteen metatarsals from the burial fit this criterion.

Amputations of the upper arm occur at midshaft of the humerus (Figure 4) (Ludlow 1867:384, Figure 248). One humerus was sawn through, and another was partially cut through by a knife.

Amputations of the forearm are performed below midshaft of the radius and ulna (Figure 5) (Ludlow 1867:384, Figure 242). Three radii and 3 ulnae fit the criteria. One radius was sawn through at the radial tuberosity, partially sawn at the midshaft, and then broken. Two radii were sawn at midshaft. One ulna was partially sawn, then broken at midshaft. Two ulnae exhibited trauma at both ends. They were sawn at the proximal end, then broken, and sawn through at the distal end.

Though the elements and modifications described above fit the criteria for amputations, the elements that exhibit false cuts, and/or are partially cut then broken, strongly suggest the cuts were on cadavers.

Modifications: Defleshing and Mounting

The presence of defleshing marks and drilling suggests the preparation of mounted medical school skeletons. Five elements show evidence of defleshing: 3 thoracic vertebrae, a first metatarsal, and a talus. Elements drilled through include 4 rib fragments drilled through at the vertebral extremity near the neck. Five elements were drilled partially:

←

Figures 1–5. Modes of amputation of limbs. Figure 1, Amputations of the thigh occur at midshaft of the femur (after Ludlow 1867:381, Figure 239); Figure 2, Amputations of the calf are performed 2 to 3 inches below the tubercle of the head of the tibia (after Ludlow 1867:386, Figures 247 and 248); Figure 3, Amputations of the foot can occur at the junction of the tarsal and metatarsals or of the calcaneus and cuboid bones (after Ludlow 1867:386, Figure 249); Figure 4, Amputations of the upper arm occur at midshaft of the humerus (after Ludlow 1867:386, Figure 248); Figure 5, Amputation of the forearm are performed below midshaft of the radius and ulna (after Ludlow 1867:386, Figure 242).

clavicle, metacarpal, 2 phalanges of the foot, rib, and a cervical vertebra.

Modifications: Dissection

Most modifications of elements in Burial 34 are associated with dissection. This includes all modifications of adult elements that do not meet the criteria for amputations as described by Ludlow (1867) and Vitali et al. (1978). This also includes all modifications to infant and fetal elements.

Dissection of adults was observed in cranial elements, 1 rib, 3 manubria, and 1 corpus sternum. Ten adult cranial fragments were sawn through at sagittal and coronal sections (Bass 1995). One right rib fragment was cut partially with a knife. Three manubria and 1 corpus sternum were cut with a knife. The cut marks do not extend superiorly past the jugular notch on the manubrium and tend to be in a superior-inferior direction. This suggests that the cut marks were made for opening and internal examination of the thoracic cavity.

The evidence of dissection and pinning down of the subadult remains include 7 elements perforated by a needle-like object, 1 element sawn through, and 16 elements cut through by a knife. The elements that exhibit perforation by a needle-like object include 5 femora (mid-shaft area), 1 unidentified long bone fragment, and 1 tibia. One infant tibia was sawn through at midshaft. The 16 elements cut through with a knife or by bone scissors at midshaft include 4 femora, 4 humeri, 1 radius, 1 tibia, and 6 ulnae.

Adult elements that do not meet the criteria for amputations, and therefore are considered dissections, include 1 fibula, 22 metacarpals, 6 phalanges of the hand, 5 tibiae, 1 unidentified long bone fragment, and 2 ulnae. The fibula was sawn through at midshaft and at the distal end. Of 22 metacarpals, 18 were cut through and 4 were partially cut through by a knife. Of the 6 phalanges of the hand 3 were cut through by a knife, 2 were cut partially by a knife, and 1 was sawn through. Of 5 tibiae, 3 were sawn through and 2 were cut through. One tibia was cut through the lateral condyle from the anterior to the posterior. One tibia was cut through the distal end and had multiple knife cuts at the distal edge; 1 tibia was sawn through at the proximal end proximal to the superior fibular articular surface, 1 tibia

was sawn at midshaft, and 1 tibia was sawn through at the distal end. One unidentified long bone fragment was cut through with a knife. Of the 2 ulnae, 1 was sawn though and 1 was cut through with a knife.

Material Culture

The artifacts in the casket were identified and catalogued by use of DiBlasi and Young (1988). The artifacts of can be separated into four functional groups: architecture, personal, clothing, and activities after Ball (1984) and South (1977).

Architectural artifacts included wire nails, flat glass, a handmade light bulb, melted lead from a tin roof, a brass thumb-tack, hardware cloth, plaster fragments, and large staples.

Personal items included a brown Bakelite plastic hair-pin. Clothing remains consisted of four porcelain milk glass buttons, a milk glass stud, and a snap closure. Shoe parts, categorized as clothing, include 6 brass grommets, 2 complete leather heels, leather sole pieces, leather upper, and leather heel pieces. Additional clothing items include a safety pin, a brass pin, an iron pin (probably a dissecting pin), the head of a straight pin, and pieces of black cloth.

Activities related artifacts include laboratory items such as a glass medicine bottle, test-tube glass, a glass base from a quart-sized chemical bottle, and a skeleton hanger. Many of the artifacts exhibited evidence of burning. Casket hardware included 15 iron strip fasteners and a casket lid closure.

Using the associated cultural remains dates, *terminus ante quem* (T.A.Q.) and *terminus post quem* (T.P.Q.) can be calculated. The T.A.Q. refers to the date before which an artifact could have been deposited, and T.P.Q refers to the date after which an artifact could have been deposited (Sharer 1993:304). The diagnostic materials include a glass medicine bottle, glass bottle base, handmade light bulb, wire nails, a brown Bakelite plastic hairpin, milk glass buttons, and milk glass stud (See Table 1).

The T.P.Q. is 1907, the earliest date for the plastic hairpin; and the T.A.Q. is 1910, the latest date from the glass medicine bottle. This suggests that the burial took place between 1907 and 1910. This would put the grave in close temporal context with the nearby 1904 grave of E. L. Rhodes (See Table 1).

Table 1. Diagnostic artifacts from Burial 34, Manslick Road Cemetery, Louisville, Kentucky.

Diagnostic artifact	Date	Source
Glass medicine bottle	1870-1910	Adams et al. 1981:294. Newman 1970:70-75
Glass bottle base	1875-Present	Fike 1987:13
Wire nails	1880-Present	Nelson 1968
Handmade light bulb	1890-1917	Pullin 1986:357
Plastic hair-pin	1907-Present	Pittman 1983
Milk glass buttons	1840-1920	Luscomb n.d.: 31, 56
Milk glass stud	1890-Present	Fike 1987:13

SOURCE OF REMAINS IN BURIAL 34: HOSPITALS AND MEDICAL SCHOOLS

In 1903 Louisville was one of the great centers of medical instruction in the United States. There were more medical colleges in Louisville than in any other U.S. city, with the possible exceptions of New York and Philadelphia (Anonymous 1903). These colleges were Hospital College of Medicine, Kentucky University, Louisville Medical College, National Medical College, University of Louisville, and Southwestern Homeopathic College (Anonymous 1903). All of the medical schools in Louisville had associated laboratories (Anonymous 1903).

Because of the considerable evidence of a fire present in the contents of Burial 34 and the indication that the human remains were used in medical teaching, historic literature was examined for fires that occurred in medical facilities or medical schools. Local newspapers were examined from 1907 to 1910. In addition, the Annual Reports of Departments for the City of Louisville were examined to find medical facility fires between 1907 and 1910. The amount of detail given in the "Report of Chief of Fire Department" from the Annual Reports varied from year to year. In 1908 fires occurred at 2 hospitals and 1 medical college; in 1910, at 1 city hospital and 1 medical college. The "Report of Chief of Fire Department" did not list names of the hospitals or medical colleges that caught fire between 1907 and 1910 nor did it give details of the damage.

CONCLUSION

Based on analysis of human remains and material culture, Burial 34 contains portions of 6 adults and 10 subadults from a medical facility fire that took place between 1907 and 1910. The modifications to specific elements

are indicative of practicing amputations, preparing medical school skeletons, and dissections. The material culture found suggests a medical school laboratory.

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Notes on Free Pericarps in Grasses (Poaceae)

David M. Brandenburg

The Dawes Arboretum, 7770 Jackstown Road SE, Newark, Ohio 43056

ABSTRACT

The typical fruit of grasses is a caryopsis, a one-seeded fruit in which the pericarp is adnate to the seed coat. Differing from typical caryopses are those in which the pericarp is free from the seed coat. Six genera with free pericarps—*Crypsis*, *Dactylis*, *Diarrhena*, *Eleusine*, *Sporobolus*, and *Zizaniopsis*—studied by Guérin in the final years of the 19th century were restudied by means of scanning electron microscopy for this paper. The caryopses of these are described and illustrated by electron micrographs. The term “modified caryopsis” is proposed for the fruits of these and other genera with such caryopses. A list of these genera is appended.

INTRODUCTION

The characteristic fruit type of the Poaceae is the caryopsis, a term coined by Richard (1808, 1811). Caryopses are dry, indehiscent, one-seeded fruits in which the pericarp (wall of the ovary) is wholly adnate to the integument of the seed. Adnation of the seed and pericarp occurs after fertilization when the outer integument and inner cell layer of the ovary wall are resorbed and the inner integument is compressed (Andersen 1927; Fahn 1974; Kennedy 1899; Rost 1973; Rost and Lersten 1973; True 1893).

Among the exceptions to the typical caryopsis are those grass genera in which the pericarp is free or loose from the seed. The genera that have free pericarps, as reported by Watson and Dallwitz (1992), are listed in the Appendix. Guérin (1898, 1899) briefly described the fruits of six of these: *Crypsis*, *Dactyloctenium*, *Diarrhena*, *Eleusine*, *Sporobolus*, and *Zizaniopsis*. He considered *Crypsis*, *Diarrhena*, and *Sporobolus* to possess true caryopses but with peculiar pericarps. He described the fruits of *Dactyloctenium* and *Eleusine* as achene-like and he considered the fruits of *Zizaniopsis* to be true achenes. Wishing to re-examine the fruits of these six genera, I completed a detailed comparison of them by use of scanning electron microscopy. The resultant data may prove useful in the interpretation of any functional significance of loose pericarps and of the evolution and classification of these genera.

MATERIALS AND METHODS

I examined the degree of fusion of pericarp and seed coat in *Crypsis*, *Dactyloctenium*, *Diarrhena*, *Eleusine*, *Sporobolus*, and *Ziza-*

nopsis. *Dactylis* and *Triticum* were employed as outgroup controls. Caryopses were selected from herbarium specimens of *Crypsis schoenoides* (Farwell 1253; OKL) (syn. *Heleocholoa schoenoides*; Hammel and Reeder 1979), *Dactylis glomerata* (Bailey and Swayne 1412; OKL), *Dactyloctenium aegyptium* (Ahles and Leisner 32441; NCU), *Diarrhena obovata* (Anderson 1072; ISC), *Eleusine indica* (Zanoni 3699; OKL), *Sporobolus giganteus* (Rice s.n.; OKL), *Triticum aestivum* (Merkel s.n.; OKL), and *Zizaniopsis miliacea* (Waterfall 7627; OKL). Cross-sections of *Crypsis*, *Dactylis*, *Diarrhena*, *Sporobolus*, *Triticum*, and *Zizaniopsis* were cut with a razor blade. All materials were mounted on metal stubs via double-stick tape and were coated with gold-palladium. Selected caryopses of *Crypsis* and *Sporobolus* were moistened with water for 2–3 minutes and observed under a dissecting microscope. One cross-section of *Sporobolus* was moistened with a drop of water after being mounted on the stub, but prior to being metal-coated for SEM. Portions of the walls of the pericarps of *Diarrhena* and *Zizaniopsis* were mechanically removed prior to mounting. Specimens were viewed in an ETEC Autoscan scanning electron microscope at an accelerating voltage of 20kV and a working distance of 20–25 mm.

Caryopses of *Zizaniopsis* were submersed in water for 30 days to test for flotation.

RESULTS AND DISCUSSION

The precise limits of the seed coat in mature caryopses is difficult to discern, as noted by Bhatnagar and Chandra (1976) and Fahn (1974) for wheat (Figure 1). A distorted layer

(Figure 2), however, presumably reflects the developmental forces that led to fusion. The caryopsis of orchard grass (*Dactylis glomerata*) (Figure 3) does not differ in any significant detail from that of wheat, the pericarp being wholly fused to the seed coat (Figure 4).

Among the atypical caryopses employed in this study, I recognize four groups based on morphology.

Sporobolus type. This type includes the caryopses of both *Sporobolus* and *Crypsis* (Figures 5–11). The caryopsis of *S. giganteus* (Figure 5) has a thick pericarp closely investing, but apparently free from, the seed (Figure 6). When the caryopsis is submersed in water for 2 or 3 minutes, the seed is extruded through a slit that opens along one side of the pericarp (Figure 7). The seeds often emerge in situ but remain partially attached to the mucilaginous pericarp (Figure 8; see also Satyamurti 1983). A similar situation was observed in *C. schoenoides* (Figures 9–11), and Arber (1934) noted that the shiny seeds of *C. aculeatus* may be found covering the panicles after heavy rains.

Eleusine type. The pericarp of the caryopses of *E. indica* appears in SEM as a papery membrane, loosely investing and free from the seed coat (Figures 12, 13). The mature seeds are either wholly enveloped in this thin pericarp (Figure 12) or sometimes have only tattered remnants of the pericarp. The mature seed coat is highly sculptured and hard (Figure 14). This coat is developed from the inner integument; the inner and middle layers of the pericarp collapse (Chandra 1963; Cummins 1929; Narayanaswami 1955). Hilu and Johnson (1997) and Phillips (1972) reported that in *E. multiflora* the grain is often shed from the floret, whereas the grain remains in situ in the other species of *Eleusine* they studied. The caryopses of *D. aegyptium* (Figure 15) follow a similar developmental pathway to those of *E. indica* (Chandra 1963) except that at maturity the seed is released from the ruptured pericarp (Figure 16).

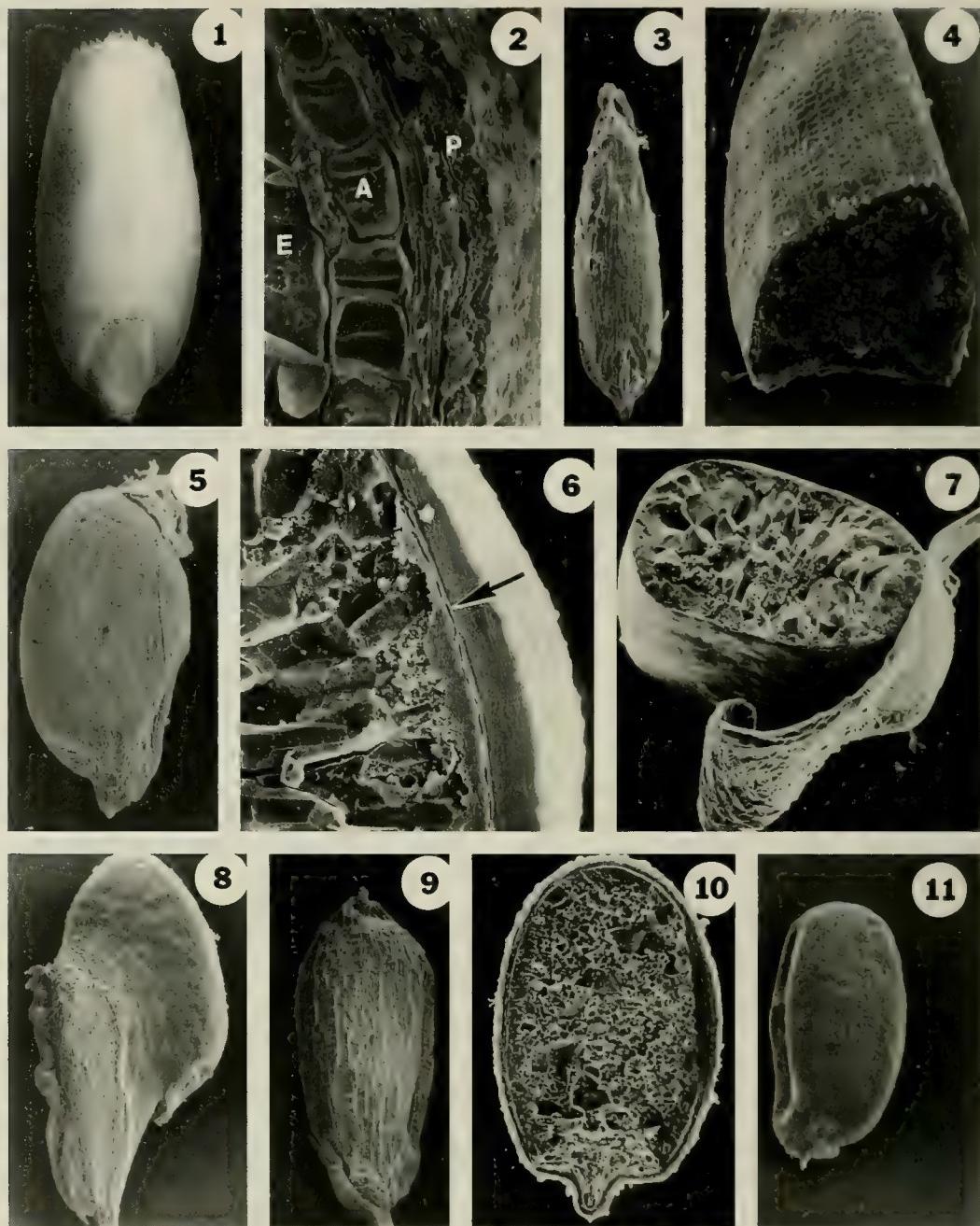
Diarrhena type. The pericarp of the caryopsis of *D. obovata* is mostly free from the seed coat (Figures 17, 18). Where free, the pericarp is thicker than in regions of fusion. The loose association between the pericarp and the seed coat can be seen in a cross-section (Figure 18). In *D. japonica* and *D. mandshurica* the pericarp is not so thick as that of

D. obovata, but the caryopses are otherwise developmentally and morphologically similar (Guérin 1899; Schwab 1971).

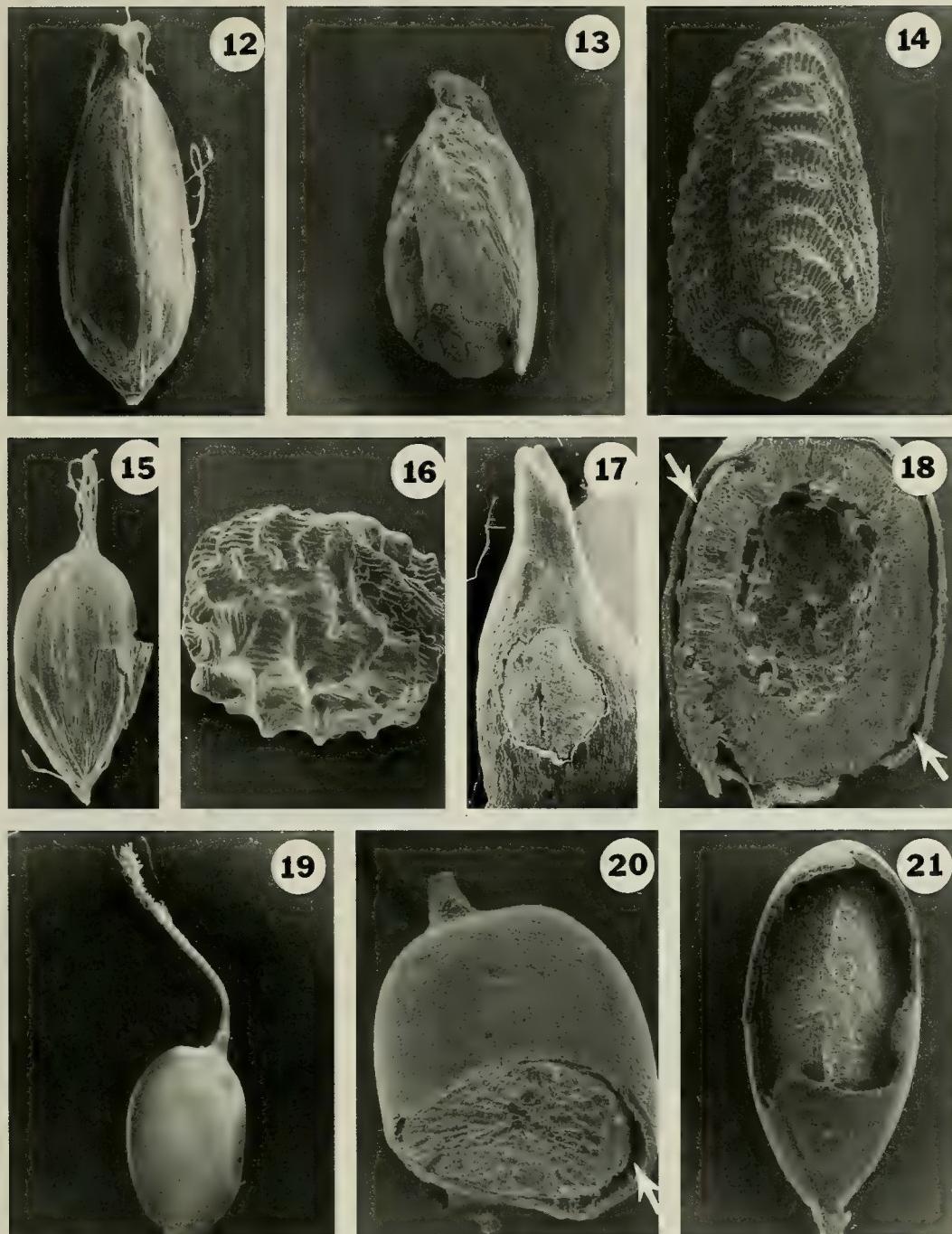
Zizaniopsis type. The last group is typified by southern wild rice, *Z. miliacea*. The asymmetrical, long-beaked caryopses of this species have thick but fragile walls with a sclerified outer pericarp (Guérin 1898) (Figure 19), superficially resembling the perigynium of a *Carex* (Terrell and Robinson 1974). Sections of the caryopsis reveals that the pericarp is fused to the seed coat only near the base (Figures 20, 21).

On the basis of their resemblance to fruit types other than the typical caryopsis, various terms have been employed to describe these grass fruits: (1) utricle—*Crypsis*, *Dactyloctenium*, *Eleusine*, and *Sporobolus*; (2) achene—*Dactyloctenium*, *Eleusine*, and *Zizaniopsis*; (3) nut or nutlike—*Eleusine* and *Zizaniopsis*; and (4) saccular—*Crypsis*, *Eleusine*, and *Sporobolus* (Allen 1980; Arber 1934; Chandra 1963; Guérin 1898; Hackel 1890; Narayanaswami 1955; Terrel and Robinson 1974). Lawrence (1951) equated "caryopsis" with "achene." Kaden (1961a, 1961b), in rejecting these and other terms such as "pseudocaryopsis," stressed the overall developmental and morphological similarity between these specialized grass fruits and the typical caryopsis: both are formed from a superior, unilocular, compound ovary; both possess a solitary, bitegmic ovule; both have a similar specialized embryo type; and both exhibit the same relative position of embryo and endosperm. I might add that the presence of a free or partially free pericarp in these six genera is also the result of evolutionary modification of the typical caryopsis. The use of other terms, such as achene would, therefore, only obscure homologous relationships. By calling them achenes, for example, and thus putting the fruits of these grasses in the same company as *Cyperus*, *Polygonum*, *Potentilla*, *Ranunculus*, and *Taraxacum*, among others, is, I suggest, untenable. (Of course, the term "achene" as defined in many classifications of fruits, embraces an overly wide range of morphology.) Thus I submit that it is preferable to refer to these fruits as modified caryopses, a term earlier used by Brandenburg et al. (1985).

Spjut's (1994) definition of a caryopsis as being a fruit "with a thin pericarp closely adhering to the testa (seed coat) and fusing with the testa



Figures 1–11. SEM's of grass fruits. **FIGURES 1, 2.** *Triticum aestivum*. **1.** Whole fruit, $\times 8.5$. **2.** Cross-section of fruit, $\times 435$. E, endosperm; A, aleurone layer; P, pericarp. **FIGURES 3, 4.** *Dactylis glomerata*. **3.** Whole caryopsis, $\times 17.5$. **4.** Cross-section of fruit, $\times 45$. **FIGURES 5–8.** *Sporobolus giganteus*. **5.** Whole fruit, $\times 35$. **6.** Cross-section of fruit, $\times 250$. Arrow = fissure between pericarp and seed coat. **7.** Cross-section with portion of pericarp peeling away after addition of water, $\times 65$. **8.** Seed emerging laterally from pericarp, in situ, $\times 25$. **FIGURES 9–11.** *Cypsis schoenoides*. **9.** Whole fruit, $\times 25$. **10.** Cross-section of fruit, $\times 70$. **11.** Seed, $\times 25$.



Figures 12–21. SEM's of grass fruits. **FIGURES 12–14.** *Eleusine indica*. **12.** Whole fruit, $\times 25$. **13.** Fruit with lower portion of pericarp mechanically removed, $\times 25$. **14.** Seed, $\times 45$. **FIGURES 15, 16.** *Dactyloctenium aegyptium*. **15.** Whole fruit, $\times 30$. **16.** Seed, $\times 45$. **FIGURES 17, 18.** *Diarrhena obovata*. **17.** Whole fruit with central portion of pericarp mechanically removed, $\times 10$. **18.** Cross-section of fruit, $\times 25$. Arrows = fissure between pericarp and seed coat. **FIGURES 19–21.** *Zizaniopsis miliacea*. **19.** Whole fruit, $\times 10$. **20.** Cross-section of fruit, $\times 25$. Arrow = fissure between pericarp and seed coat. **21.** Fruit after removal of beak and portion of pericarp, $\times 25$.

only in the hilar region" (see also Sendulsky et al. 1987) is at variance with the usual definition of the term, i.e., a fruit in which the pericarp is *fully adherent* to the seed coat. To describe the relationship between pericarp and seed coat other definitions use other terms, e.g., "adherent" (Swartz 1971), "adnate" (Gleason and Cronquist 1991), "united" (Allaby 1992), "firmly united" (Core 1955), "grown fast to the pericarp" (Featherly 1965 [1959]), "fused" (Harris and Harris 1994), "integrally fused" (Terrell and Robinson 1974), "closely fused" (Lazarides 1970), and "ovary wall stuck to the seed coat" (Gould 1978). Other variants include "pericarp usually indistinguishable from the seed" (Lindley 1853) and "a seed inseparably enclosed in a very thin pericarp" (Baumgardt 1982). This plethora of terminology is both unfortunate and confusing.

There is evidence for the possible selective advantages for two of the four types of modified caryopses that I recognize; both are related to dispersal. The air space between the free pericarp and the seed in caryopses of *Zizaniopsis* allows for their buoyancy in water, thereby permitting an effective means of dispersal for this aquatic species. Submersed mature caryopses from herbarium specimens immediately floated to the surface and floated for 30 days, after which time the experiment was terminated. Floating fruits have also been observed in native populations of *Z. miliacea* (personal observation). (Holmes and Stalling [1990] stated that "the fruits [of *Zizaniopsis*] float as long as the lemmas and paleas remain attached.") In the *Sporobolus* type, mucilage from the gelatinous pericarps is transferred to the seeds, permitting them to adhere to passing animals (Davidse 1986); later, upon drying, the seeds fall to the ground (Bor 1960).

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APPENDIX

The grass genera listed below are those for which the pericarp is reported as free by Watson and Dallwitz (1992).^{1,2} In parentheses following some of the names are free-pericarp data as given in that work when these differ from simply “pericarp free.” I have elected to include no genus said to have a free pericarp unless Watson and Dallwitz ascribed that feature to it. The generic circumscriptions are those of Watson and Dallwitz.

ARUNDINOIDEAE

Danthoneiae

Dregeochloa Conert

Elytrophorus P. Beauv.

Hakonechloa Makino

Molinia Schrank (loosely adherent, reluctantly separable)

Pentameris P. Beauv.

Pentaschistis (Nees) Spach (free or fused or loosely adherent)

Pyrrhanthera Zotov

Tribolium Desv. (loosely adherent)

Stipeae

Anisopogon R.Br. (free or loosely adherent)

Psammochloa A. Hitchc.

BAMBUSOIDEAE

Bambuseae

Actinocladum McClure ex Soderstrom

Cephalostachyum Munro

Greslania Bal.

Metacalamus Benth.

Merostachys Spreng. (fused or loosely adherent)

¹ These genera represent but ca. 11% of the 785 grass genera listed in Watson and Dallwitz (1992). No pericarp data at all are given for most genera in that work, indicating the need for more investigation of caryopsis morphology in Poaceae. Such investigation will certainly increase the count of genera with free pericarps.

² For the genus *Stiburus* Stapf Watson and Dallwitz (1992) stated “pericarp fused (probably)”; Phillips (1951), though, stated “pericarp delicately hyaline, free, swelling slightly in water.”

- Neohouzeaua* A. Camus
Oreobambos K. Schum.
Perrierbambus A. Camus
Pseudocoix A. Camus
Pseudostachyum Munro
Pseudoxystyantha Soderstrom & Ellis
 (loosely adherent below or fused above)
Puelia Franch.
Schizostachyum Nees
Teinostachyum Munro
Brachyelytreae
Brachyelytrum P. Beauv. (loosely adherent to fused, removable with difficulty)
Diarrhenae
Diarrhena P. Beauv.
Oryzeae
Luziola A.L. Juss.
Zizaniopsis Doell & Aschers.
Phaenospermataeae
Phaenosperma Munro ex Benth.
Streptochaetaceae
Streptochaeta Schrad. (loosely adherent to fused)
- CHLORIDOIDEAE**
- Chlorideae**
Acamptoclados Nash (free or loosely adherent)
Acrachne Wright & Arn. ex Chiov.
Afrotrichloris Chiov.
Apochiton C.E. Hubb.
Astrebla F. Muell.
Austrochloris Lazarides
Brachychloa Phillips
Calamovilfa Hackel
Chaetostichium (Hochst.) C.E. Hubb.
 (loosely adherent, removable when soaked)
Chloris O. Swartz (free to fused)
Cladoraphis Franch.
Coelachyropsis Bor
Coelachyrum Hochst. & Nees
Crypsis Aiton
Cypholepis Chiov.
Dactyloctenium Willd.
Daknopholis W. Clayton
Diplachne P. Beauv. (free or loosely adherent or fused)
Drake-Brockmania Stapf (loosely adherent, removable when wet)
Eleusine Gaertn.
Enteropogon Nees (free or fused)
Entoplocamia Stapf
- Eragrostis* N.M. Wolf (fused usually or loosely adherent, rather readily detachable in some species, or free)
Eustachys Desf. (loosely adherent or fused)
Heterocarpha Stapf & C.E. Hubb.
Ischnurus Balf.
Leptochloa P. Beauv. (free or loosely adherent or fused)
Leptothrium Kunth (loosely adherent)
Lepturus R. Br. (loosely adherent)
Lintonia Stapf
Lophacme Stapf (loosely adherent, easily removable after soaking)
Neesiochloa Bush
Ochthochloa Edgew.
Odyssea Stapf
Opizia J. & C. Presl
Oropetium Trin. (loosely adherent, removable when soaked)
Pringleochloa Scribnier
Psammagrostis C. Gardner & C.E. Hubb.
Psilolemma Phillips (loosely adherent, removable when soaked)
Pterochloris A. Camus (loosely adherent)
Richardsiella Elffers & Kennedy O'Byrne
Saugetia A. Hitchc. & Chase (pericarp free?)
Schoenfeldia Kunth
Sclerodactylon Stapf
Spartina Schreber (loosely adherent or fused)
Sporobolus R. Br.
Tetrachne Nees (fused or loosely adherent, removable with difficulty after soaking)
Tetrapogon Desf.
Thellungi Stapf
Uniola L.
Urochondra C.E. Hubb.
- POOIDEAE**
- Aveneae**
Dasypoa Pilger
Zingeria P. Smirnov
- Poae**
Dryopoa Vick. (loosely adherent, readily removable)
- UNCERTAIN AFFINITY**
- Amphipogon* R.Br. ARUNDINOIDEAE?
 Danthoniae?
- Urochlaena* Nees ARUNDINOIDEAE Danthoniae?

The *Journal of the Kentucky Academy of Science*: Indexing and Availability of a Kentucky-Based Resource

J. B. Hill and Cherie Madarash-Hill

Sims Memorial Library, Southeastern Louisiana University, Hammond, Louisiana 70402

ABSTRACT

Throughout their history, the state academies of science have promoted and disseminated local and regional scientific research through the publication of refereed journals and conference proceedings. Since 1923, the Kentucky Academy of Science has published a journal featuring its members' research. Over the years, the *Journal of the Kentucky Academy of Science* and its predecessor, the *Transactions of the Kentucky Academy of Science*, has received selective indexing, but today it is indexed comprehensively by the *State Academy of Science Abstracts* as well as selectively by numerous life science indexing and abstracting services.

BACKGROUND

During the late 1990s, we conducted a detailed examination of the publications of the state academies of science (Hill and Madarash-Hill 2000). It was found that while the publications of the state academies of science are generally not considered part of the core literature of the sciences, they are an important source of state and regional scientific research. In general, the state academies journals are inexpensive, peer reviewed, multi-disciplinary publications that contain a preponderance of articles in the life and earth sciences. Indexing varies widely among the titles but for most of the journals the level of indexing is adequate, particularly since the inception of *State Academies of Science Abstracts*.

Following the original examination of the publications of the state academies of science, we conducted an update that focused on the recent developments in electronic publishing by the state academies (Hill and Madarash-Hill 2001a). The study found that only a few state academies of science (California, Kansas, Mississippi, North Dakota, and Oklahoma) have incorporated electronic publication and distribution of their journals and proceedings; most have continued to rely on print as their publication medium.

We are currently examining the indexing of individual state academies of science publications in greater depth. An examination of the *Journal of the Mississippi Academy of Sciences* was published in 2001 (Hill and Madarash-Hill 2001b). An examination of the *Journal of the Kentucky Academy of Science* follows.

HISTORY OF THE *JOURNAL OF THE KENTUCKY ACADEMY OF SCIENCE*

Founded in 1914, the Kentucky Academy of Science is the state's largest professional scientific organization. The early history of the Kentucky Academy of Science as well as the history of the *Transactions of the Kentucky Academy of Science* has been chronicled by T. M. George (George 1992, 1993).

The Kentucky Academy of Science held its first meeting at the Physics Building of the University of Kentucky in 1914 with 25 scientists in attendance. Dr. Paul Boyd, professor of mathematics at Kentucky State University, served as the first chairman; Dr. Charles Robinson of the University of Louisville served as secretary. In 1920, Dr. Boyd conducted a survey of state academies of science and concluded that the organizations did have a role to play in the scientific community (Midgette 1991). Respondents to Boyd's survey emphasized that many scientists who could not travel to national meetings rarely missed state gatherings. Furthermore, they declared that state meetings provided an ideal starting point for younger scholars and that state academy meetings offered a common ground for professional scientists and interested amateurs (Boyd 1920). At the eighth annual meeting in 1921, the Kentucky Academy of Science formally became affiliated with the American Association for the Advancement of Science (AAAS); it has continued the affiliation to this day.

Between 1916 and 1923, the Academy published abstracts of papers given at meetings in *Science*, the journal of the AAAS. However, after 1923, this arrangement was terminated

due to the space limitations of the journal. This led to the creation of the *Transactions of the Kentucky Academy of Science*. Dr. William Rouse Jillson, the state geologist, not only served as the first editor but also underwrote the cost of publishing the first volume of the *Transactions* (George 1993).

In 1998, the Academy changed the name of the *Transactions* to the *Journal of the Kentucky Academy of Science*. Published semianually, the *Journal* is a peer-reviewed publication that provides a forum for publishing the results of original investigations in scientific fields and serves as a record of the Academy's scientific papers, notes, reviews, and annual meeting abstracts.

In addition to the Academy members, other researchers have access to the *Journal of the Kentucky Academy of Science* through individual and library subscriptions. An examination of the OCLC database indicates that 148 libraries throughout the United States and Europe have holdings for the *Journal* and/or *Transactions*.

In addition to the *Journal of the Kentucky Academy of Science*, the Academy also publishes a newsletter. While the *Journal* is available only in print, issues of the Academy's quarterly *Kentucky Academy of Science Newsletter* are accessible as PDF files via the Academy's web site at <http://kas.wku.edu/kas/newsletter.asp>.

INDEXING OF THE JOURNAL OF THE KENTUCKY ACADEMY OF SCIENCE

Like all state academies of science journals, the *Journal of the Kentucky Academy of Science* has received uneven indexing over the years. Due to its multi-disciplinary nature, most indexing sources index the *Journal* selectively. Only those articles with subjects relevant to the index or database are included. For example, a zoology database, such as *Zoological Record*, only indexes articles that are relevant to the study of zoology and ignores the others.

This selective indexing makes it difficult to determine the precise level of indexing of the *Journal*. Only a few articles may be indexed by the subject-specific indexes and there may be a few years between articles that are indexed. In our original study (2000), we considered a state academy of science title to be

indexed by an index or database if there was a citation to any article published in the 1990s. Based on that criterion, we found that on average, state academy journals were indexed by eleven indexes or databases. We found that the *Journal of the Kentucky Academy of Science* or the *Transactions of the Kentucky Academy of Science* was indexed in eight databases.

Based on our recent reexamination of leading indexes and databases, it appears that the *Journal of the Kentucky Academy of Science* is currently indexed comprehensively in *State Academies of Science Abstracts*. The *Journal* is indexed selectively in *Aquatic Sciences and Fisheries Abstracts*, *Biological Abstracts*, *CSA Biological Sciences*, *Environmental Sciences & Pollution Management*, *Pollution Abstracts*, *Water Resources Abstracts*, and *Zoological Record*. Additional indexes and databases have indexed the *Journal* and/or *Transactions* selectively in the past and may include citations and abstracts from the *Journal* in future years. Details of the indexing follow.

Agricola

Compiled by the National Agricultural Library of the U.S. Department of Agriculture, *Agricola* contains citations to agricultural literature, providing bibliographic access to books, papers, journal articles, pamphlets, government documents, research reports, conference proceedings, and audiovisual materials. Coverage is from 1970 to the present. *Agricola* encompasses all aspects of agriculture and allied disciplines, including animal and veterinary sciences, entomology, plant sciences, forestry, aquaculture and fisheries, farming, agricultural economics, extension and education, food and human nutrition, and earth and environmental sciences.

An examination of the *Agricola* database indicates that 133 articles published in the *Transactions of the Kentucky Academy of Science* from 1980 to 1993 were referenced in the database. Unfortunately, *Agricola* appears to have discontinued indexing the *Transactions* as well as all other state academies of science journals in 1995.

Aquatic Sciences and Fisheries Abstracts

Aquatic Sciences and Fisheries Abstracts, produced by Cambridge Scientific Abstracts

(CSA), is one of the primary databases in the study of the aquatic sciences. The database provides coverage of the aquatic science literature since 1978 and currently monitors over 5000 serial publications as well as books, reports, conference proceedings, translations, and "limited distribution literature." Print indexes generated from this database include ASFA 1: *Biological Sciences & Living Resources*; ASFA 2: *Ocean Technology, Policy & Non-Living Resources*; ASFA 3: *Aquatic Pollution & Environmental Quality*; ASFA *Marine Biotechnology Abstracts*; and ASFA *Aquaculture Abstracts*. CSA routinely scans and selectively indexes the *Journal of the Kentucky Academy of Science* for inclusion in the *Aquatic Sciences and Fisheries Abstracts* database and the five related print indexes.

Biological Abstracts

Biological Abstracts is one of the best sources of indexing for the *Transactions of the Kentucky Academy of Science* and the *Journal of the Kentucky Academy of Science*. Produced by BIOSIS, a not-for-profit organization, *Biological Abstracts* is the most comprehensive database of journal literature in the life sciences. It currently indexes articles from over 4000 serials and contains ca. 8 million bibliographic records. Coverage is from 1926 to the present in the print index, *Biological Abstracts*, and from 1969 to the present in the electronic database. An examination of the *Biological Abstracts* database indicates that 550 articles/abstracts from the *Transactions of the Kentucky Academy of Science* and the *Journal of the Kentucky Academy of Science* have been indexed since 1969.

CAB Abstracts

CAB International, having begun as the British Commonwealth Agricultural Bureaux, is now an international, non-profit organization that produces two major agricultural/biological science databases, *CAB Abstracts* and *CAB Health*, as well as more than 40 subject-specific abstracting journals.

CAB Abstracts is a bibliographic database with over 3 million citations and abstracts from 1973 to the present. The database indexes the literature of agriculture, forestry, human health and nutrition, animal health, and natural resources. *CAB Health* is a smaller da-

tabase with ca. 700,000 records from 1973 to the present. The database indexes the literature dealing with human nutrition; parasitic, communicable, and tropical diseases; and medicinal plants.

CAB International routinely scans over 7000 scientific titles for possible inclusion in *CAB Abstracts*, *CAB Health*, and the subject specific abstracting publications. An examination of *CAB Abstracts* indicates that 34 articles/abstracts from the *Transactions* were indexed between 1974 and 1985. However no recent articles from the *Journal* have been indexed.

CSA Biological Sciences

CSA Biological Sciences is an interdisciplinary database produced by Cambridge Scientific Abstracts that provides citations and abstracts to research in agriculture, biomedicine, biotechnology, ecology, veterinary science, and zoology since 1982. Print indexes generated from this database include *Agricultural & Environmental Biotechnology Abstracts*; *Amino Acids, Peptides & Proteins* (archive); *Animal Behavior Abstracts*; ASFA *Aquaculture Abstracts*; ASFA *Marine Biotechnology Abstracts*; ASFA 1: *Biological Sciences & Living Resources*; *Bioengineering Abstracts*; *Biological Membranes* (archive); *Biotechnology Research Abstracts* (archive); *Calcium & Calcified Tissue Abstracts*; *Chemoreception Abstracts*; *CSA Neurosciences Abstracts*; *Ecology Abstracts*; *Entomology Abstracts*; *Genetics Abstracts*; *Health & Safety Science Abstracts*; *Human Genome Abstracts* (archive); *Immunology Abstracts*; *Medical & Pharmaceutical Biotechnology Abstracts*; *Microbiology Abstracts* Section A: *Industrial & Applied Microbiology*; *Microbiology Abstracts* Section B: *Bacteriology*; *Microbiology Abstracts* Section C: *Algology, Mycology & Protozoology*; *Nucleic Acids Abstracts*; *Oncogenes & Growth Factors Abstracts*; *Toxicology Abstracts*; and *Virology & AIDS Abstracts*. CSA routinely scans and selectively indexes the *Journal of the Kentucky Academy of Science* for inclusion in the *CSA Biological Sciences* database and the 26 related print indexes.

Chemical Abstracts

Since 1907, the Chemical Abstracts Service, a division of the American Chemical Society,

has indexed and summarized chemistry-related articles from more than 40,000 scientific journals, as well as patents, conference proceedings, and other documents pertinent to chemistry, life sciences, and related fields. As the premier index of chemical literature, *Chemical Abstracts* provides abstracts for more than 22 million documents. Between 1965 and 1987, *Chemical Abstracts* indexed 55 articles and abstracts from the *Transactions of the Kentucky Academy of Science*. However, no recent articles from the *Journal* have been indexed.

Environmental Sciences & Pollution Management

Environmental Sciences & Pollution Management is a multidisciplinary database produced by Cambridge Scientific Abstracts that covers the environmental sciences literature since 1981. The database currently contains more than 1.5 million records with its abstracts and citations being drawn from ca. 6000 serials, including scientific journals, conference proceedings, reports, monographs, books, and government publications. Cambridge Scientific Abstracts routinely scans and selectively indexes the *Journal of the Kentucky Academy of Science* for inclusion in the *Environmental Sciences & Pollution Management* database.

Fish & Fisheries Worldwide

Fish & Fisheries Worldwide is produced by National Information Services Corporation (NISC USA) and provides more than 365,700 citations and abstracts on all aspects of ichthyology, fisheries, and related aspects of aquaculture. It provides coverage of thousands of journal articles, books, monographs, pamphlets, conference proceedings, symposia, government reports, theses, and dissertations and is derived from a number of fish databases, including *FISHLIT* (1985–present), *Fisheries Review* (1971–present), Fish Subset of *Medline* (1966–present), *Fishing Industry Research Institute Database*, the Fish and Wildlife Reference Service's *Fish Database* (1960–present), *Castell's Nutrition References* (1970–present), the National Oceanic & Atmospheric Administration's *Aquaculture* database (1970–1984) and *Fish Health News*.

Fish and Fisheries Worldwide indexed 91

articles/abstracts published in the *Transactions* between 1972 and 1994. These articles originated from *Fisheries Review*, an index that was produced by the United States National Biological Service until 1995. When NISC took over the maintenance of the index, it discontinued indexing the *Transactions* and other state academies of science journals.

GeoRef

Produced by the American Geological Institute, *GeoRef* provides comprehensive coverage of the geology and geophysics literature of North America since 1785 as well as international literature since 1933. Included in the database are references and abstracts for papers from over 4500 serials and other publications of geological and earth science societies.

GeoRef corresponds to the print publications: *Bibliography and Index of North American Geology*, *Bibliography of Theses in Geology*, *Geophysical Abstracts*, *Bibliography and Index of Geology Exclusive of North America*, and *Bibliography and Index of Geology*. The database includes citations to articles from the *Transactions of the Kentucky Academy of Science* and over 3500 additional journals as well as books, maps, reports, theses, and dissertations.

An examination of *GeoRef* indicates that 69 articles from the *Transactions of the Kentucky Academy of Science* were indexed between 1924 and 1976. However, no recent articles from the *Journal* have been indexed.

Pollution Abstracts

Pollution Abstracts is a multidisciplinary database produced by Cambridge Scientific Abstracts that covers the pollution-related literature since 1981. The database includes both scientific research and government policy information, taken from 1147 serials, as well as conference proceedings and reports. The print index, *Pollution Abstracts*, is generated from this database. Cambridge Scientific Abstracts routinely scans and selectively indexes the *Journal of the Kentucky Academy of Science* for inclusion in the *Pollution Abstracts* database and print index.

Science Citation Index and Journal Citation Reports

Produced by the Institute of Scientific Information (ISI), the *Science Citation Index* (*SCI*) provides indexing for ca. 3700 science and technology journals covering more than 100 disciplines. The expanded format of the *Science Citation Index*, available through the *ISI Web of Science* and the *SciSearch* database, provides indexing for more than 5800 journals. In addition to providing multidisciplinary coverage of scientific literature, the *Science Citation Index* also serves as the primary record of scientific citation levels by indicating how often publications are cited.

The *Science Citation Index* does not index the *Journal of the Kentucky Academy of Science*, as ISI indexes publications from only three state academies of science (i.e., New York, Ohio, and Texas). However, the *Science Citation Index* and *Web of Science* do provide access to *Journal* and *Transactions* articles through cited references, i.e., the citations that appear in the bibliographies of the papers/journals that ISI does index. Since 1974, articles from the *Journal* or *Transactions* have been cited 301 times in the journals indexed by *Science Citation Index*.

In addition to publishing the *Science Citation Index*, ISI publishes an annual *Journal Citation Reports* (*JCR*), tabulated from the past two years of *Science Citation Index*. Included for each of the ca. 5000 journals covered by *Journal Citation Reports* is the number of articles published, number of citations, impact factor, immediacy index, and cited half-life. Of the measures published in *Journal Citation Reports*, the most commonly examined in journal comparisons is the journal impact factor. ISI calculates a journal's impact factor by dividing the number of citations (found in the articles that ISI indexes) to the journal's articles published in the two previous years by the total number of articles published in those two years. Since ISI includes in the *JCR* only those titles it indexes, ISI has not calculated an impact factor for *Journal of the Kentucky Academy of Science*.

State Academies of Science Abstracts

State Academies of Science Abstracts (*SASA*) provides the most comprehensive in-

dexing coverage of the *Journal of the Kentucky Academy of Science* and most of the other publications of the state academies of science. *SASA* completely indexes all full-length papers and proceedings abstracts published in the publications of 40 state academies of science. The database's coverage of the publications of the Kentucky Academy of Science includes every article and abstract published in the *Journal* and *Transactions* since 1967.

Water Resources Abstracts

Water Resources Abstracts is a database of water-related scientific and technical literature published since 1967. Cambridge Scientific Abstracts produces the database and draws its citations and abstracts from more than 1000 journals, as well as books, conference proceedings, technical reports and government publications. Prior to 1995, the United States Geological Survey produced the database under the name *Selected Water Resources Abstracts*. Since taking over the indexing, CSA has broadened the scope of coverage by including more international publications. CSA routinely scans and selectively indexes the *Journal of the Kentucky Academy of Science* for inclusion in the *Water Resources Abstracts* database.

Wildlife & Ecology Studies Worldwide

Wildlife & Ecology Studies Worldwide is produced by the National Information Services Corporation (NISC USA) and provides indexing and abstracting of scientific literature on wild mammals, birds, reptiles, and amphibians. *Wildlife & Ecology Studies Worldwide* includes the content from a number of current and ceased indexes and databases, including *Wildlife Review Abstracts* (1935 & earlier to present), *Swiss Wildlife Information Service* (SWIS, 1974–present), U.S. Fish and Wildlife Reference Service's *Wildlife Database* (1960–present), *BIODOC* (1970–1999), *Waterfowl & Wetlands Bibliography* (*Duckdata*, 1838–2000), *IUCN-The World Conservation Union* (1946–present), *Natural & Cultural Heritage of Africa* (1960–present), and the *Afro-Tropical Bird Information Retrieval Database*.

Wildlife & Ecology Studies Worldwide indexed 89 articles/abstracts published in the *Transactions* between 1952 and 1994. These articles were originally indexed in *Wildlife Re-*

view, an index that was produced by the United States National Biological Service until 1996. When NISC took over the maintenance of the index, it discontinued indexing the *Transactions of the Kentucky Academy of Science* as well as other state academies of science journals.

Zoological Record

As the premier zoology database, *Zoological Record* provides international coverage of zoological literature with particular emphasis on systematic/taxonomic information. Coverage is from 1870 to the present in the print index. The online version covers 1978 to the present. BIOSIS, the producer of *Zoological Record*, routinely scans over 6000 titles, including the *Journal of the Kentucky Academy of Science*. An examination of the online version of *Zoological Record* indicates that 281 articles/abstracts from the *Transactions of the Kentucky Academy of Science* and the *Journal of the Kentucky Academy of Science* have been indexed from 1978 to present.

Other Indexing/Abstracting Sources

Several other indexing/abstracting sources provide limited coverage to articles in the *Journal of the Kentucky Academy of Science* or the *Transactions* but have not indexed any recent articles from the journal. These indexes include *Ingenta*, *GeoBase*, *ProceedingsFirst*, and *PapersFirst*.

While not an index per se, the *Ingenta* database is a searchable gateway of more than 11 million citations from over 20,000 journals, including the *Transactions of the Kentucky Academy of Science*. Electronic, fax, and Ariel document delivery is available for a fee for millions of articles. An alerts service called "Reveal Research Alerts" enables customers to stay current with their personal research by signing up to receive e-mailed citations from their favorite journals. *Ingenta* includes issues of the *Transactions of the Kentucky Academy of Science* between 1990 and 1995.

Produced by Elsevier Science, *GeoBase* indexes 2000 journals as well as books, monographs, conference proceedings, and reports on geography, geology, and ecology. The database corresponds to the print publications: *Geographical Abstracts: Part A-G*; *International Development Abstracts*; *Geographical*

Abstracts series (Geophysics and Tectonics, Economic Geology, Paleontology and Stratigraphy, Sedimentary Geology), Mineralogical Abstracts, and *Ecology Abstracts*. An examination of *GeoBase* indicates that six articles from the *Transactions of the Kentucky Academy of Science* were indexed in the early 1980s.

ProceedingsFirst and *PapersFirst* are databases produced by OCLC that provide citations for every congress, symposium, conference exposition, workshop, and meeting received at the British Library since 1993. The databases contain records for the 77th annual meeting of the Kentucky Academy of Science, which was published in the 1992 issue of the *Transactions of the Kentucky Academy of Science*.

CONCLUSION

As all publications of the state academies of science, the *Journal of the Kentucky Academy of Science* has been unevenly indexed over the years. However, with its inclusion in the *State Academies of Science Abstracts*, the *Journal* is currently being comprehensively indexed for the first time. The *Journal* is also indexed selectively by eight databases, including two of the premier life science databases (i.e., *Biological Abstracts* and *Zoological Record*), and 31 indexing/abstracting print journals. As a result, research published in the *Journal* is widely accessible to scientists outside the academy's membership, allowing the *Journal of the Kentucky Academy of Science* to continue to be an important vehicle for the distribution of local and regional scientific research.

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Comparing Kentucky-grown Freshwater Prawn with Marine Shrimp: Results of a Taste Test

Siddhartha Dasgupta and Susan Templeton

Aquaculture Research Center, Kentucky State University, Frankfort, Kentucky 40601

ABSTRACT

A blind taste test was conducted for three boiled seafood products among 112 participants at Kentucky State University. The products were previously frozen freshwater prawn tails (Product A), previously frozen marine shrimp tails (Product B), and fresh prawn tails (Product C). After tasting, participants were surveyed in order to elicit their preferences for different product attributes, their rating of the overall acceptability of products, and their willingness to purchase the products.

The data were statistically analyzed and the following are included in the main results: (1) participants rated the appearance of prawn higher than the appearance of marine shrimp, (2) participants exhibited a higher probability of purchasing frozen prawn than frozen marine shrimp, (3) older respondents gave higher-than-average ratings to the appearance and odor of fresh prawn and flavor of marine shrimp, and (4) males were more inclined to purchase fresh prawn than were females.

INTRODUCTION

Freshwater prawn (*Macrobrachium rosenbergii*) is a relatively new aquaculture crop in Kentucky and neighboring states. Currently, Kentucky and Tennessee have an excess of 40 and 80 water hectares in prawn production, respectively. Dasgupta and Tidwell (2003) showed that small-scale freshwater prawn (hereafter denoted only as prawn) farming offers a good income potential; however, their results indicate that average breakeven prices ranged from \$8.60/kg to \$17.28/kg (year 2000 dollars), depending upon stocking density, feeding rate, and pond management technology. Such high breakeven prices make marketing prawn challenging, particularly when the average wholesale price of Gulf of Mexico shrimp was \$4.93/kg for 2001 (Dasgupta and Tidwell 2003).

In wholesale marketing, U.S. prawn has to compete with marine shrimp and imported prawn, and the resulting low prices are not attractive to small-scale producers. The last 5 years of production and marketing of prawn in Kentucky have shown that the only profitable marketing channels are either direct sales to consumers or sales to white tablecloth restaurants. In order to ensure long-term survival of these markets and to allow opening of new markets, it is important for industry specialists to understand consumer perceptions of prawn.

Dillard et al. (1986) conducted some pre-

liminary studies investigating consumer acceptance of prawn in Mississippi restaurants. They found that 77 % of consumers (sample size: 852) rated prawn similar to marine shrimp. Eighty-eight percent of consumers indicated that they would be repeat customers for prawn if it were available in restaurants. Recently, Woods (1999) did a market development study for prawn in Kentucky and Ohio. Consumer surveys, based on taste testing of prawn, were conducted in three cities to elicit consumer preferences for different attributes of prawn (sample size: 122). Of many attributes, taste and freshness were considered to be most important. Kentucky consumers indicated strong preference for a "grown in Kentucky" label, but this was not important to out-of-state consumers. A focus group study (78 observations) was also conducted to compare frozen prawn versus marine shrimp. The cooked products were randomly given to individual tasters, who completed a questionnaire after tasting the products. The results indicated that proportionately more consumers believed that marine shrimp have firmer flesh and stronger "shrimp-like" flavor than freshwater prawn.

This paper reports the results of a taste test of Kentucky grown prawn and marine shrimp conducted among 112 subjects at Kentucky State University. The test was performed to evaluate similarities and differences in consumer perception of prawn and marine

Table 1. Summary statistics (mean \pm SD) for different product attributes and demographics for prawn and marine shrimp taste test ($N = 112$). Means within each row followed by different letters are significantly different ($P \leq 0.05$).

Attribute	Product		
	Previously frozen prawn (A)	Previously frozen marine shrimp (B)	Fresh prawn (C)
Appearance ¹	7.79 (± 1.13) a ²	6.89 (± 1.85) b ²	7.50 (± 1.47) a ²
Odor ¹	6.59 (± 1.98)	6.04 (± 2.29)	6.50 (± 1.76)
Texture ¹	7.30 (± 1.46)	7.16 (± 1.59)	7.31 (± 1.49)
Flavor ¹	7.32 (± 1.52)	6.98 (± 2.09)	7.01 (± 1.90)
Overall acceptance ¹	7.47 (± 1.37)	7.17 (± 1.87)	7.17 (± 1.74)
Willingness to buy ³	Yes: 74% a	Yes: 54% b	Yes: 645 ab
Demographics ⁴			
Gender	Male: 48%		
Age groups	Under 20s: 14%; 20s: 25%; 30s: 24%; 40s: 23%; 50+: 14%		
Smoking habit	Smoker: 21%		

¹ Answers on appearance, odor, texture, flavor and overall acceptance were rated on a 1 to 9 scale, where 1: dislike extremely and 9: like extremely.

² Average rating for appearance was significantly different for the three products (F -statistic = 10.327, p -value = 0.00); multiple comparison test indicated significant differences in average ratings between products A and B, and B and C; no significant differences in average ratings between products A and C. Average ratings of all other product attributes were not significant across the three products.

³ The 'willingness to buy' table entry indicates the percentage of 112 respondents indicating that they were willing to purchase the product. Chi-square test statistic, comparing the equality of the proportion of respondents willing to purchase the three products (null hypothesis) = 10.255 ($P = 0.006$).

⁴ Information on other socio-economic/demographic variables such as income, education, and race were unavailable in the survey data.

shrimp. This paper has two broad purposes: (1) investigating consumer perceptions of prawn and marine shrimp and (2) exploring the causality of consumer ratings of product attributes and willingness to purchase. It contributes to the pool of knowledge that assists marketers in identifying specific population niches that would demand freshwater prawn.

MATERIALS AND METHODS

A taste test was conducted among 112 randomly selected participants at Kentucky State University. Individuals were given three products: boiled prawn that was previously frozen (product A), boiled marine shrimp that was previously frozen (product B), boiled fresh prawn (product C). Care was taken to ensure that the three products were accessible to most consumers: products A and C were farmed-raised in Kentucky and product B (Key West pink shrimp, *Penaeus duorarum*) was purchased from a grocery store in Frankfort, Kentucky. Fresh marine shrimp was not included in this study because it was unavailable in the area. Tail sizes of frozen/fresh prawn and marine shrimp were kept very similar to reduce the effect of size on differential product perceptions of consumers. This taste test was blind, i.e., products were not identified to the participants prior to tasting, and the sequence in which the three products were offered to the tasters was randomly changed.

from individual to individual. After tasting each product, the participants rated the product and they were asked to rinse their mouth prior to tasting the next product. A survey was conducted in which respondents indicated their preference for products A, B, and C with respect to the following attributes: appearance, odor, texture, flavor, and overall acceptability (hereafter known as simply "Overall"), on a 1 to 9 scale, where 1 was dislike extremely, 5 was neither like nor dislike, and 9 was like extremely. Participants were also asked to indicate whether they would purchase each of the products, provided the price of the three products was similar. The survey ended with questions about the participant's gender, age, and smoking habits. Table 1 contains summary statistics for some of the survey questions.

We used various statistical analyses to investigate consumer preferences for the three products A, B, and C. Analysis of variance and multiple comparison tests were used to compare mean ratings of the three; principal component analysis (PCA) was performed on consumer ratings of product attributes to investigate correlations across different products and to identify new, meaningful underlying variables and causal mechanisms among product attribute ratings. PCA investigated if the consumer ratings for the product attributes represented independent attitudinal dimensions or did the ratings measure a select num-

ber of underlying attitude-based components. The methodology of PCA involved standardizing input variables (i.e., variables used in PCA) to have a zero mean and unit variance. The goal was to extract a few components, such that each component accounted for the dispersion of several input variables. Hence, each component would be a latent variable, containing information of several observable variables. As such, a useful component would be one that would explain at least a single unit of variance; otherwise, the component would explain less variance than a standardized input variable. The variance of a component is an eigenvalue of the correlation matrix associated with the data (Johnson 1998). Hence, we selected those principal components that would explain more than one unit of total variance, i.e., their associated eigenvalues were greater than 1.

We used Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy to determine if the data were suitable for PCA analysis. The null hypothesis (H_0) for Bartlett's test indicates that the data came from a population in which the input variables were uncorrelated, i.e., acceptance of H_0 would indicate that PCA was unsuitable on the data set. The KMO measure compares observed correlations to partial correlations among input variables, to investigate if the data were sufficiently correlated to make PCA meaningful. In general, if two input variables shared a common component, their partial correlations would be small and the value of the corresponding KMO measure would be close to 1. If the input variables were not measuring a common component, their partial correlation would be large and the corresponding KMO measure would be close to zero. Consequently, if the KMO index were near zero, that data would be unsuitable for PCA analysis.

We also investigated potential relations between respondent preferences and sample segments based on gender, age and smoking habits. Information on other demographic variables such as race, education, and income were unavailable for the analyses. The "smoking habits" question was included because it was felt that smoking would affect tasting. The methodology used here was consistent with Engle and Kouka (1995) and Kinnucan et al.

(1993). Kinnucan et al. (1993) provided the following conceptual framework for their technique: "Perceptions are formed by abstracting observed product characteristics into a limited number of dimensions such as taste, nutritional value and cost. These perceptual dimensions form the basis for preference formation . . . preferences are in turn assumed to determine the specific products that a consumer considers in a choice situation" (p. 275). A structural model of evaluating causality of consumer decisions following this approach involved estimating the following functions: (1) relation between attribute rankings (e.g., appearance, odor, texture, and flavor) and socio-demographic characteristics of respondents and (2) the relation between purchasing decision and attribute ranking/demographics. Since specific details of such models are available in Engle and Kouka (1995), we chose not to reiterate their development. Instead, we exhibit the structural model by adopting it from Engle and Kouka (1995):

- (1) Rank of product attribute_i = f_i (Demographic parameters),
- (2) Probability [Willingness to purchase_i = 1] = g_i (Ranking of product attributes_i, Demographic parameters), for i = product A, B, C.

Here, f_i represents linear functions; equation (1) is estimated using ordinary least square regression, and g_i represents the logistic cumulative distribution function, i.e., equation (2) is estimated using logistic regression (Engle and Kouka 1995). Willingness to purchase the products was quantified by three dichotomous variables: Buy A, Buy B, and Buy C. The response variable Buy A is defined by: Buy A = 1 implies that the respondent is willing to purchase product A; Buy A = 0 otherwise. Buy B and Buy C are similarly defined.

RESULTS

Table 1 reports averages and standard deviations for the attribute ratings of the three products. Average ratings for product appearance were significantly different across the three products (F -statistic = 10.327, P = 0.00). Multiple comparison tests indicated that average appearance ratings were not significantly different between products A and C; however, average ratings were higher for prod-

Table 2. Correlation of the first three principal components (PC 1, 2 and 3) with attributes of products A, B, and C (i.e., component loadings) and the percentage of explained variance associated with PC1, PC2, and PC3. PC1 is highly correlated with attributes of product A and C, i.e., PC1 refers to consumer opinion of prawn. Similarly, PC2 is highly correlated with different attributes of product B, i.e., PC2 aggregates consumer attitude of different marine shrimp characteristics. PC3 represents a latent variable that contrasts attributes of products A and C. N = 112.

Variable	PC1	PC2	PC3
Appearance A	0.479	-0.232	0.121
Appearance B	0.342	0.375	0.016
Appearance C	0.590	-0.092	-0.016
Odor A	0.581	-0.202	0.246
Odor B	0.256	0.684	-0.054
Odor C	0.551	-0.080	-0.128
Texture A	0.688	-0.230	0.139
Texture B	0.286	0.648	0.118
Texture C	0.568	0.072	-0.187
Flavor A	0.737	-0.253	0.236
Flavor B	0.392	0.800	0.135
Flavor C	0.672	-0.013	-0.415
Overall A	0.730	-0.389	0.297
Overall B	0.373	0.816	0.153
Overall C	0.704	-0.008	-0.421
Purchase A	0.546	-0.440	0.330
Purchase B	0.146	0.844	0.122
Purchase C	0.614	-0.098	-0.422
Eigenvalues	5.292	3.634	2.318
Percentage of explained variance	29.402%	20.186%	12.878%

ucts A and C, respectively, when compared with product B. This suggests that respondents were able to differentiate the appearance of prawn tails from shrimp tails. Table 1 also shows that average ratings on other attributes (odor, texture, flavor, and overall acceptance) were not significantly different across the three products. Table 1 reports the percentage of respondents exhibiting a willingness to purchase the three products: a chi-squared test indicated that the respondents' willingness to purchase differed across the three product types (test statistic = 10.255, $P = 0.006$). Multiple comparisons indicated that a proportionately higher number of consumers showed a willingness to purchase product A over product B (test statistic = 9.360, $P = 0.002$); however, there were no significant differences in the willingness to buy products B and C (test statistic = 2.232, $P = 0.135$), and products A and C (test statistic = 0.021, $P = 0.885$).

Principal component analysis further explored underlying correlations in the data set. The components corresponding to the three largest eigenvalues, individually accounted for 29%, 20%, and 13% of the total variation, respectively (Johnson 1998). The remaining

components each accounted for a minuscule portion of the total variance, and they were rejected from the results. The Bartlett's test of sphericity produced a Chi-squared test statistic of 1,292.933 ($df = 153$, $P = 0.00$). This indicated that the input variables were not from an uncorrelated population, i.e., the population correlation matrix was not an identity matrix. The KMO measure was 0.73, i.e., the degree of common variance among input variables was middling, i.e., the extracted components would account for a fair amount of variance of the input variables.

Table 2 indicates the component loadings associated with the first three components (PC1, PC2, and PC3). The variables that have high loadings in PC1 include Appearance C, Odor A, Odor C, Texture A, Texture C, Flavor A, Flavor C, Overall A, and Overall C. The variables that have high loadings for PC2 include Odor B, Texture B, Flavor B, and Overall B, Purchase B. Clearly, PC1 is strongly correlated to many attributes of products A and C, i.e., PC1 is a latent variable that represents aggregate characteristics of both fresh and previously frozen cooked prawn. PC2, which is orthogonal to PC1 (i.e., refers to a different dimension of consumer perception), incorpo-

rates attributes of marine shrimp. This reveals that the respondents were able to distinguish between freshwater prawn and marine shrimp as different products. In PC3, Flavor C, Purchase C, and Overall C are all strongly (albeit negatively) correlated to the component; Purchase A is positively correlated to PC3. An intuitive interpretation of PC3 is less obvious: it represents a latent variable that contrasts products A and C.

Product attribute ratings were regressed with respect to consumer characteristics to determine any potential linkages. Each product's attribute ratings were regressed with respect to gender, age, and smoking habit: other demographic information was unavailable. Only three attributes ratings were found to have significant causality with consumer characteristics: appearance and odor of C and flavor of B. The following results were obtained (*t* ratios appear below corresponding coefficient estimates):

$$\begin{aligned} \text{Appearance C} &= 6.849 + 0.126 \text{Gender} \\ &\quad 9.174 \qquad 0.452 \\ &\quad + 0.039 \text{Smoker} + 0.634 \text{ (Age)} \\ &\quad \qquad 0.116 \qquad 2.221 \\ &\quad \geq 30) + \text{residual} \\ \text{Odor C} &= 5.869 + 0.210 \text{Gender} \\ &\quad 6.615 \qquad 0.627 \\ &\quad - 0.139 \text{Smoker} + 0.933 \text{ (Age)} \\ &\quad \qquad -0.344 \qquad 2.716 \\ &\quad \geq 30) + \text{residual} \\ \text{Flavor B} &= 6.045 - 0.420 \text{Gender} \\ &\quad 5.751 \qquad -1.066 \\ &\quad - 0.506 \text{Smoker} + 0.926 \text{ (Age)} \\ &\quad \qquad -1.190 \qquad 2.303 \\ &\quad \geq 30) + \text{residual} \end{aligned}$$

R^2 for the above regressions were 4.6%, 6.8%, and 7.5%, respectively, which partially reflects the cross-sectional form of the dataset (R^2 in cross-sectional data regressions tend to be lower than in regressions using time-series data (Nakamura and Nakamura 1998)). Similar low fit is prevalent in other preference analyses where consumer preference ratings were regressed against socio-demographic characteristics, for example Dasgupta et al. (2000), Engle and Kouka (1995), and Foltz et al. (1999). The above results indicate that respondents 30 years or older tended to have

higher ratings, on average, with respect to appearance and odor of fresh prawns (product C) and flavor of frozen marine shrimp (B), than younger respondents.

The final portion of the consumer perception model investigated potential linkages between consumer characteristics and preferences with respect to purchasing decisions. Table 3 reports the results of three Logit regressions with Buy A, Buy B, and Buy C as dependent variables. Goodness-of-fit is reported for each regression using the percentage of accurate predictions and likelihood ratio index (Greene 1990). Clearly, gender was the only consumer characteristic that directly affected purchasing decisions: males were more inclined to buy product C than females. Other results indicated that a high rating on odor and flavor of product A tended to improve its likelihood to be purchased. The flavor rating tended to have similar effects on the purchasing probability of the corresponding product. In addition, Table 3 shows that a high odor rating for products A and B, respectively, decreased and increased the purchasing likelihood for product B. A poor rating on the appearance of A and the texture of B was related to a high probability of purchasing C. Interestingly, a high rating on the flavor of product B was associated with a high probability of purchasing product C.

Apart from outlining the obvious (i.e., flavor was important in making purchasing decisions), the Logit regression results suggested that product freshness was valued by a segment of the respondents: individuals with low ratings on attributes of frozen prawn and shrimp preferred to purchase fresh prawn. The results also indicated that individuals who liked the flavor of boiled marine shrimp displayed a willingness to purchase fresh prawn.

DISCUSSION AND CONCLUSIONS

The following conclusions can be drawn from the blind taste test: (1) consumers rated the appearance of prawn higher than the appearance of marine shrimp (Table 1); (2) consumers exhibited a higher probability of purchasing frozen prawn than frozen marine shrimp (Table 1); (3) consumers rated fresh and frozen prawns similarly, and differently from marine shrimp (Table 2); (4) older consumers gave higher-than-average ratings to the

Table 3. Results from binomial Logit regression (Greene 1990) of willingness to purchase products A, B, and C, with respect to consumer demographics and beliefs about product attributes. Three dependent variables (Buy A, Buy B, and Buy C) are defined by: Buy A = 1 implies that a respondent is willing to purchase product A; Buy A = 0 otherwise. Buy B and Buy C are similarly designed for products B and C, respectively. N = 106.

Independent variable	Dependent variable		Dependent variable Buy C ¹ Estimated coefficient	
	Buy A ¹			
	Estimated coefficient	Estimated coefficient		
Intercept	-2.471	-0.001	-6.306 ¹	
Gender	-0.904	-0.401	-1.221 ¹	
Age: 30s and 40s	-0.806	-0.591	-0.291	
Age: 50+	1.183	0.707	0.592	
Smoker	-1.088	-0.354	0.920	
Appearance A	0.389	-0.630	-0.687 ¹	
Appearance B	-0.001	0.422	-0.001	
Appearance C	-0.173	0.373	0.543 ¹	
Odor A	0.412 ¹	-0.316 ¹	0.260	
Odor B	-0.302	0.334 ¹	-0.254	
Odor C	0.006	-0.008	-0.007	
Texture A	0.294	0.299	0.380	
Texture B	-0.155	0.054	-0.666 ¹	
Texture C	-0.133	-0.356	0.293	
Flavor A	0.820 ¹	-0.524	-0.598	
Flavor B	-0.098	1.010 ¹	0.430 ¹	
Flavor C	0.008	-0.336	1.391 ¹	
Accurate predictions	90%	83%	88%	
Likelihood ratio index	52%	51%	54%	

¹ This indicates that the estimated coefficient is significantly different from zero for $\alpha = 5\%$.

appearance and odor of fresh prawn and flavor of marine shrimp; (5) males were more inclined to purchase fresh prawn than were females (Table 3); and (6) consumers who rated the flavor of marine shrimp highly also tended to exhibit a strong willingness to purchase fresh prawn (Table 3).

Results of this paper are useful to develop marketing strategies that will make prawn appealing to consumers. For example, the results from appearance, odor, texture, and taste attributes can be used to differentiate freshwater prawn from marine shrimp: domestic prawn can be fresh, having a less fishy odor and a more delicate flavor than marine shrimp. Since older consumers show a greater inclination towards prawn, future advertisements should include healthful characteristics such as the lower in iodine and cholesterol content in prawn when compared with marine shrimp.

As a result of inherent similarities, freshwater prawn and marine shrimp are often grouped together in wholesale and retail markets. This is detrimental to the U.S. prawn industry because marine shrimp can be profitably sold at a lower price than domestic prawn at any market level (Dasgupta and Tidwell

2003). However, the results of this research showed that, once prawn and shrimp were tasted, consumers were able to differentiate the products (i.e., they were able to tell that prawn and shrimp were different), even in a blind test. While the greater willingness to purchase frozen prawn over frozen marine shrimp was an encouraging result, the caveat is that the participants in the taste test were informed that the two products were similarly priced. Since the results showed that consumers rate both prawn and shrimp highly, product pricing would be one of the chief determinants in making a purchasing decision.

The current prawn-marketing situation in Kentucky relies heavily on niche marketing, where fresh prawn are supplied to a specific consumer sector that is willing to pay a premium for quality. The domestic prawn industry's survival, in competition with marine shrimp in larger scale markets, will depend on greater product differentiation of prawn, consumer education on the uniqueness of prawn, and lowering of production cost.

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Nanotechnology, or Things Granny Taught Me

Stephen S. Tillett

Herbario Dr. Víctor Manuel Ovalles (MYF), Facultad de Farmacia, Universidad Central de Venezuela,
Caracas, Venezuela

Alirica I. Suárez and Natalia Sánchez P.

Laboratorio de Productos Naturales, Facultad de Farmacia, Universidad Central de Venezuela, Caracas, Venezuela

ABSTRACT

The presence of valerenic acids has been demonstrated in “valeriana” (*Pfaffia iresinoides*), a South American plant of the amaranth family (Amaranthaceae). These compounds were previously unknown in that family.

One of the bases of ethnopharmacological study is the testing of traditional medicinal plants, which frequently results in a high percentage of validation of uses. These are the home cures that have been handed down from generation to generation; many are being lost as children move to the cities and as grandparents die. In the Americas, many medicinal plants have been introduced, mostly from Europe, but also other countries, or adapted from indigenous uses. Nevertheless, the rationale for the traditional users, that of constant empirical testing, is not always the case with today's population. Frequently, names of European plants are applied to native plants that may be completely unrelated but have some similarity of form, color, or odor.

This is very frequent in Latin America, and misuse, or false usage, has been promoted by the economic boom in “natural products,” related to the very high cost of patent medicines; a purist tends to become suspicious. One example in Venezuela is the “salvia real” (royal sage) (*Pluchea odorata*), a bush of the sunflower family (Compositae), growing to over 2 meters tall, not at all related to the European sage (*Salvia officinalis*) of the mint family (Labiatae). It is used for various health problems, infrequently as a condiment, but not as a stomachic, digestive, or emmenagogue. The only reason for the name might be the plant's slight pungent odor and its fuzzy, greyish green leaves, somewhat similar in appearance but very much larger than those of sage. A form of *Piper cernuum*, a shrub 1 to 2 meters tall, with leaves to 40 × 20 cm and long, slender, white spikes of minute flowers, is called “menta” (mint) in one

area of the country because the crushed leaves have a vague minty odor.

Another example is “valeriana” (*Pfaffia iresinoides*) of the amaranth family (Amaranthaceae) (Figures 1–2), sold by herb vendors as a tranquilizer, promoting sleep. As a taxonomist, botanical assessor, and collaborator with various pharmacognosic, pharmacological, and chemical projects, SST has been bothered by this plant for some years, particularly after finding it used by a local natural products company as if it were true European valerian (*Valeriana officinalis*) of the valerian family (Valerianaceae), easily recognized, even by a blind person, because it has the characteristic strong odor of the family—dirty socks. They are, of course, in no way related, and SST considered that it must surely be a gross misuse. This native “valeriana” does have a large carrot-like root, and the small fruits are surrounded by the long hairs of the sepals, characteristics vaguely reminiscent of the true valerian, but otherwise the plant is quite dissimilar as it is much larger and coarser and grows in the hot lowlands, not high in the Andes, where a few native species of *Valeriana* do occur.

SST pesters his chemical colleagues with problems like this and finally got our Natural Products Laboratory to check it out as a thesis project for NSP, a chemistry student under the supervision of AIS. The initial analyses started as a comparison with true valerian—one has to begin somewhere. After months of extraction, fractionation, and testing, the negative results, for the presence of true valerian compounds, were prepared for presentation the following Monday in the poster session of our local scientific meeting (Sanchez P. et al.



Figure 1. *Pfaffia iresinoides*, a South American plant of the amaranth family (Amaranthaceae) that has been shown to contain valerenic acids.



Figure 2. *Pfaffia iresinoides*. Close-up of flowers.

2002). After pharmacological testing, this could be the basis for a health service warning that the plant is innocuous and not acceptable as a substitute for true valerian. From some intuition, and the receipt of a new protocol for testing valerian just received at a European congress, another run was made and, lo and behold, the final tests on Saturday showed the presence of valerenic acids—the active principles in the true valerian—but the absence of the valepotriates, which are the source of the dirty-socks odor. A really surprising turn of events, as valerenic acid is quite infrequent in the plant kingdom, and not reported for the amaranth family (Gibbs 1974). Of course, the poster had to be quickly remade.

Posterior pharmacological tests, yet unpub-

lished, have shown that the extract is as effective as Bromazepam (similar to Valium) in experiments with rats. Further analyses are under way to search for the possible presence of other sedative or synergistic compounds.

You were right after all, Granny; so brew us up a "valeriana" tea, we've not been sleeping very well these last few nights.

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Abstracts of Some Papers Presented at the 2002 Annual Meeting of the Kentucky Academy of Science

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AGRICULTURAL SCIENCES

Impact of soil management and insecticide residues on urease and invertase activity. GEORGE F. ANTONIOUS, Land-Grant Program, Department of Plant and Soil Science, Kentucky State University, Frankfort, KY 40601.

The effect of a silty-loam soil mixed with yard-waste compost at 50 t/acre (on dry weight basis), fescue strips, and two botanical insecticides (pyrethrins and Neemix-4E) on activities of the enzymes hydrolyzing urea (urease) and sucrose (invertase) in the rhizosphere of potato plants was investigated under field conditions. Soil urease and invertase activities were monitored in the compost amended soil, soil collected from fescue strips, and in adjacent bare soils during 35 days following treatment. Soil urease activity was increased by application of yard-waste compost compared to untreated soil which provides evidence of increased soil microbial population following application of compost. Some transitional effects on urease activities were observed following pyrethrins and Neemix-4E application; these effects were neither drastic nor prolonged enough to be considered deleterious to the enzymes important to soil fertility. No relationship was found between invertase activity and the two management practices or soil organic matter content. It is suggested that application of botanical insecticides like pyrethrins and Neemix-4E may be useful in delaying urea fertilizer mineralization. The present study may also provide information on urease activity as a sensitive bioindicator of soil quality that reflects the effect of land management on soil quality and may assist land managers in monitoring long-term productivity and sustainability of agricultural lands.

Mass spectrometric analysis of ginger rhizomes and wild tomato extracts. GEORGE F. ANTONIOUS*, Land-Grant Program, Department of Plant and Soil Science, and TEJINDER S. KOCHHAR, Department of Math and Sciences, Kentucky State University, Frankfort, KY 40601.

Analysis of leaf extracts of the wild tomato *Lycopersicum hirsutum* f. *typicum* (Solanaceae) indicated the presence of zingiberene, curcumene, and other lipophilic secondary metabolites on the leaves of two accessions (PI-127826 and PI-127827). No zingiberene or curcumene were detected in *L. hirsutum* f. *glabratum*, *L. pennellii*, and *L. pimpinellifolium* accessions. Mass spectrometric analysis of fresh ginger rhizomes *Zingiber officinale* (Zingiberaceae) showed fragments with molecular ions at m/e 202 and at m/e 204, which are consistent with the assignment of the molecular formula of curcumene ($C_{15}H_{26}$) and zingiberene ($C_{15}H_{24}$), respectively, known as major constituents of ginger rhizomes. The sesquiterpene hydrocarbon zingiberene [5-(1,5-dimethyl-4-hexenyl)-2-

methyl-1,3-cyclohexadiene] has been shown to have a considerable spectrum of biological activity such as antiviral, antiulcer, and antifertility effects. Zingiberene is also associated with the resistance to the Colorado potato beetle (*Leptinotarsa decemlineata*), and beet armyworm (*Sophoptera exigua*). The two sesquiterpene hydrocarbons in *L. hirsutum* f. *typicum* leaves were present at 145 and 14.6 µg zingiberene and curcumene, respectively, per cm² of leaflet surface area of accession PI-127827, and 110 and 58 µg zingiberene and curcumene, respectively, per cm² of leaflet surface area of accession PI-127826. This study indicated that *L. hirsutum* f. *typicum* foliage can be explored for mass production of zingiberene and curcumene.

A simplified procedure for quantification of sugar-esters in wild tomato. KENYARI L. MOORE*, GEORGE F. ANTONIOUS and LISA M. HAWKINS, Land-Grant Program, Department of Plant and Soil Science, Kentucky State University, Frankfort, KY 40601.

Both native and greenhouse populations of *Lycopersicon pennellii* (a wild relative of commercial tomato, *L. esculentum*) have sticky exudates known as sugar-esters (glycolipids) covering their leaves and stems. *L. pennellii* resistance to important vegetable pests has been attributed primarily to type-IV glandular trichome secretions. This study was initiated to extract and quantify sugar-esters in four wild tomato accessions (PI-503516, PI-246502 = LA 716, PI-365972 = LA 1277 and PI-414773) of *L. pennellii* which have long been known to entrap insect pests in their sticky exudates. Extracts of glandular trichomes containing sugar-esters were prepared in chloroform and reconstituted in ethanol. A simplified micro-colorimetric method was used for sugar-esters quantification. The method is based on breaking the ester-bonds between the sugar moiety and the fatty acids using sodium hydroxide and quantifying free glucose molecules liberated after hydrolysis. This simple, rapid, and accurate procedure can be used for screening wild tomato accessions of *L. pennellii* for sugar-ester contents.

Effect of class A biosolids on bell pepper yields. MATTHEW A. PATTERSON* and GEORGE F. ANTONIOUS, Land-Grant Program, Department of Plant and Soil Science, Kentucky State University, Frankfort, KY 40601.

The Center for Disease Control estimates that 50% of the nearly 8 million tons of commercial, industrial, and municipal waste biosolids generated in the United States are currently recycled as soil amendments. Biosolid recycling reduces the need for landfill disposal and/or incineration while enhancing plant growth on reclamation sites,

forest lands, and agricultural lands. The objective of this study was to compare bell pepper yields from biosolid amended soils to yields obtained from yard waste compost amended and unamended soils under field conditions. Field studies were conducted on a Lowell silty loam soil located at the Kentucky State University Research Farm, Franklin County, KY. Six replicates of each soil amendment were applied at a rate of 50 tons/acre on a dry weight basis to standard USLE research plots (22 x 3.7 m, 10% slope). Aristotle X3R hybrid bell pepper seedlings were planted in rows 2 m apart along the contour of the slope. After 72, 86 and 100 days, mature green peppers were harvested from each plot, weighed, and graded according to USDA standards for sweet peppers. Total harvest weight and weights of US Fancy, US #1, US #2, and culls obtained from each soil amendment will be presented and discussed.

Performance of methyl ketones against the sweet potato whitefly (*Bemisia tabaci*) and the Colorado potato beetle (*Leptinotarsa decemlineata*). LISA M. HAWKINS^{*1}, GEORGE F. ANTONIOUS¹ and ALVIN M. SIMMONS²
¹Land-Grant Program, Department of Plant and Soil Science, Kentucky State University, Frankfort, KY 40601 and
²U.S. Vegetable Laboratory, USDA/ARS, Savannah Highway, Charleston, SC 29414.

The insecticidal performance of four methyl ketones (undecanone, dodecanone, tridecanone, and pentadecanone) against the sweet potato whitefly (*Bemisia tabaci*) and the Colorado potato beetle (*Leptinotarsa decemlineata*) under laboratory conditions is explored in this study. An 8 hr no-choice bioassay in Petri-dishes was used for evaluating the performance of methyl ketones against adult whiteflies. Fourth instar larvae of Colorado potato beetle were exposed to potato leaf disks (2.5 cm i.d.) treated with each of the four methyl ketones in a 24 hr no-choice bioassay. LC₅₀ values for whiteflies averaged 19.9, 20.6, 15.3, and 16.2 µMole/cm² of treated surface area for undecanone, dodecanone, tridecanone, and pentadecanone, respectively. LC₅₀ values for Colorado potato beetle were 2.3, 1.5, 5.2, and 1.0 µMole/cm² of treated leaf surface area for undecanone, dodecanone, tridecanone, and pentadecanone, respectively. Insecticidal performance of methyl ketones against whiteflies and Colorado potato beetles under greenhouse and field conditions and the impact of UV-light on their persistence and efficiency remain to be answered.

Mitigation of pesticide residues on highly erodible Lands. SAYWARD B. MCKEE* and GEORGE F. ANTONIOUS, Land-Grant Program, Department of Plant and Soil Science, Kentucky State University, Frankfort, KY 40601.

Agricultural activity is the leading non-point source pollution statewide which affects 89% of the streams surveyed. The use of pesticides in plant protection releases large quantities of pesticides into rivers and streams. Studies were conducted at the Kentucky State University Re-

search Farm to determine the influence of sewage sludge treated with lime for land farming and yard-waste mixed with native soil at 50 t/acre (on dry weight basis) on the persistence and mobility of pesticides (Treflan and Diazinon) in soil and runoff water. Our main objective is to develop management alternatives that mitigate environmental degradation while maintaining agricultural productivity and profitability. Residues of pesticides were significantly ($P < 0.05$) higher in amended soils than no-mulch soils which indicates that the organic fraction in amended soils is primarily responsible for pesticides adsorption and/or degradation rather than clay. Concentration of pesticides in runoff water collected from the amended soils was lower than no-mulch soil. These low residues of pesticides in runoff water provide the allowable safety needed for human health and environmental quality.

Seasonal variation in trichome counts and contents in wild tomato accessions. PASANO B. BOJANG*, GEORGE F. ANTONIOUS, Land-Grant Program, Department of Plant and Soil Science, and TEJINDER S. KOCHHAR, Department of Math and Sciences, Kentucky State University, Frankfort, KY 40601.

Wild species of plants contain numerous non-nutritive, bioactive compounds known as phytochemicals. Many of these compounds cause the leaf to be less suitable for insect growth and may influence leaf palatability. A significant positive correlation was found between the intensity of wild tomato leaf trichomes (leaf hairs) and mortality of many vegetable insects. Type-IV and type-VI glandular trichomes on the leaves of three accessions of *Lycopersicon hirsutum* f. *typicum*, six accessions of *L. hirsutum* f. *glabratum*, two accessions of *L. pennellii*, and one accession of *L. pimpinellifolium* were counted monthly (January to December, 2001). Crude extracts prepared from the leaves of each species were also prepared in n-hexane and chloroform, separated, purified, and quantified using GC/MSD for biochemical composition. Monthly variations in concentration of methyl ketones, sesquiterpene hydrocarbons, and sugar esters (glycolipids) were determined. Considerable variations in biochemical constituents among accessions were detected. The selected wild tomato accessions containing high levels of each constituent and the potential of their future use as botanical insecticides prepared from wild tomato leaf extracts will be presented and discussed in detail.

Effect of increasing lipid levels on growth and body composition in largemouth bass, *Micropterus salmoides*, fed isonitrogenous diets. LEIGH ANNE BRIGHT*, SHAWN D. COYLE and JAMES H. TIDWELL, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601.

Largemouth bass were graded to a similar size (16.3 g ± 2.4) and randomly stocked at 25 fish/aquaria into fifteen, 113.6-L glass aquaria, with three replicates per treatment. Fingerlings were fed twice daily to apparent satiation one of 5 isonitrogenous diets containing 42% protein

and either 0, 5, 10, 15 or 20% added lipid with protein/energy ratios of 137, 120, 106, 95 and 86 mg·kcal, respectively. At harvest, there were no significant differences ($P > 0.05$) in average weight, specific growth rate, average individual gain, survival, percent protein deposited, or protein efficiency ratio. Fish fed with 15 and 20% added lipid had a significantly lower ($P > 0.05$) feed conversion ratio and total feed consumption than fish fed with lower lipid inclusions. The hepatosomatic indices for fish fed 10, 15 and 20% added lipid were significantly higher ($P > 0.05$) than in fish fed the 0 and 5% added lipid diets. Proximate analyses indicated that feeding the 15 and 20% added lipid diets significantly increased ($P > 0.05$) whole body lipid levels and the 10, 15 and 20% added lipid diets significantly increased lipid concentrations in white muscle. Since the basal diet (control 0% added) contained 4% lipid from protein sources, these results would indicate that 4–9% lipid supports good growth in juvenile largemouth bass when fed 42% protein. Protein sparing was not demonstrated as protein utilization was not increased with added lipid.

The effect of production intensification on water quality in pond growout of the freshwater prawn, *Macrobrachium rosenbergii*. AKUA HENAKU-LARBI*, JAMES TIDWELL, SHAWN COYLE and LEIGH ANNE BRIGHT, Kentucky State University, Aquaculture Research Center, Frankfort, KY 40601.

The freshwater prawn, *Macrobrachium rosenbergii*, is becoming a commercially important species in the south central United States including Kentucky. In pond production, several different management techniques and levels of production are being employed by growout farmers. This study compared the relative effect of production levels commonly used by growers in the region on pond water quality. Three different stocking densities (35,000, 48,000 and 61,000/ha and corresponding increased feed rates) were evaluated in 0.04 ha ponds with two, three, and two replicate ponds per treatment, respectively. A 28% protein steam pelleted diet was fed twice daily according to a feed chart based on the number and size of prawn. The 61,000/ha treatment also used a higher protein feed (36% protein) for the last 6 weeks of production to compensate for the decreased availability of natural foods at the higher stocking density. The effect of these management practices on water quality was measured as total ammonia-nitrogen, nitrite-nitrogen, and pH which were taken once per week. After 106 days, the overall means for total ammonia-nitrogen were significantly higher ($P < 0.05$) in ponds stocked at 61,000/ha (0.69 mg/L) than in ponds stocked at either 35,000 (0.51 mg/l) or 48,000/ha (0.47 mg/l), which were not significantly different ($P > 0.05$) from each other. Nitrite-nitrogen was also significantly higher ($P < 0.05$) for prawn stocked at 61,000/ha (0.04 mg/L) than for prawn stocked at either 35,000 (0.01 mg/l) or 48,000/ha (0.01 mg/l), which were not significantly different ($P > 0.05$) from each other. The overall means for pH were not significantly different (P

> 0.05) by treatment and averaged 8.3 for all three treatments combined. These data demonstrate that stocking densities and feed rates used in commercial production and nutrient inputs can significantly impact water quality; however, the measured values in this study were probably not sufficient to cause negative impacts on prawn health or growth.

Comparative efficiency of anesthetics for the freshwater prawn, *Macrobrachium rosenbergii*. THOMAS BEAVERS*, JAMES TIDWELL, SHAWN COYLE, DAVID YASHARIAN and LEIGH ANNE BRIGHT, Kentucky State University, Aquaculture Research Center, Frankfort, KY 40601.

The freshwater prawn is a commercially important culture species in the south central United States including Kentucky. Two major constraints in the commercial culture of the freshwater prawn in the United States are the difficulty in live transportation of seed-stock to growout ponds, and live transportation of pond harvested prawns to distant markets due to high mortality in transport largely due to negative interactions in prawn. The use of anesthetics could greatly improve transport survival, which would increase survival in growout production and greatly expand the marketing potential for live product sales. There are currently no proven anesthetic agents for use in prawns. In this study, we compared the efficiency of five anesthetics commonly used in finfish: Tricaine methane sulfonate (MS-222), 2-phenoxyethanol, quinaldine sulfonate, clove oil, and Aqui-S. Anesthetics were applied at 100, 200 and 300 mg/l in three replicate 6 l glass containers containing 5 juvenile prawns. Observations were made every 3 minutes for 1 hour to determine the relative level of sedation of the prawns exposed to the different chemical and treatment rates. MS-222, 2-phenoxyethanol, and clove oil were determined to be ineffective at all rates tested. Quinaldine sulfonate and Aqui-S were effective as anesthetics at all rates tested. After a 1 hour recovery period, prawn subjected to the 300 mg/l concentration suffered 60% mortality in the Aqui-S treatment and 20% mortality in the quinaldine treatment. The 100 mg/l treatment was effective for Aqui-S with no observed mortality following the recovery period, where some mortality was observed in all the quinaldine treatments. Based on these data, 100 mg/l Aqui-S performed the best for use as a safe anesthetic in the freshwater prawn. Additional research is needed to determine optimal time and dose relationships to minimize stress and injury during harvest, handling and transportation of the freshwater prawn.

Effects of stocking different fractions of size graded juvenile prawns on production and population structure during growout. JAMES H. TIDWELL* and SHAWN D. COYLE, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601.

Size grading juvenile prawns prior to pond stocking is used to disrupt negative social interactions. Animals from the upper end of the size range can outperform ungraded

animals by 20–50%, but reports differ on the performance of the lower grade fraction. While some studies indicate lower grade animals may equal or surpass ungraded animals if the growing season is sufficiently long, the growing season in the temperate region is limited to 110–130 days so the performance of the lower grade fraction is evaluated under these conditions. Prawn juveniles that had been nursed 60-days were separated into three groups using a #13 bar grader (0.5 cm spacing): ungraded controls, upper grade, and lower grade. Ponds were randomly assigned to receive one of three treatments with three replicate 0.04 ha ponds per treatment. Artificial substrate was added to ponds at a rate to increase available surface area by 50%. After 105 days there was no significant difference ($P > 0.05$) in survival of prawns from the ungraded, low grade, or high grade fractions (overall survival 88%). Total production and average individual weight was significantly greater ($P < 0.05$) in prawns from the high grade fraction (3310 kg/ha; 43 g) while FCR was significantly lower (2.0). There was no significant difference in total production of prawns stocked from the ungraded (2888 kg/ha; 36 g) or low graded fractions (2560 kg/ha; 35 g). Marketable production (kg/ha) was significantly higher ($P < 0.05$) in the high grade treatment based on minimum marketable weights of both 20 g and 30 g. Impacts of grading procedures on population structures were much more pronounced in females than in males. Within females, high graded animals had a significantly higher ($P < 0.05$) percentage of sexually mature reproductive females (85%) than ungraded and low graded animals. In summary, stocking of the upper graded group increased total production, average weights, and marketable production. There was no difference in low graded and ungraded animals in the above variables.

Acute toxicity of copper to juvenile freshwater prawns, *Macrobrachium rosenbergii*. SHAWN COYLE*, IMAZE MARIAN OSUNDE and JAMES TIDWELL, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601.

Copper sulfate (CuSO_4) is an algicide that is commonly used for phytoplankton and filamentous algae control and has been used as a therapeuticant in aquaculture. The objectives of this study were to determine the acute toxicity of copper sulfate and the safe level for use in freshwater prawn, *Macrobrachium rosenbergii*, production ponds in a high calcium and alkalinity environment. Six concentrations of copper sulfate (0, 0.2, 0.4, 0.6, 0.8 and 1.0 mg/l) were tested on 10 juvenile prawns ($0.32g \pm 0.16$) in 8L glass aquaria for 48 hours with three replicate aquaria per treatment. Concentrations of calcium hardness and alkalinity were set at 100 mg/l using calcium chloride and sodium bicarbonate, respectively. After 48 hours, survival of the control treatment (0% CuSO_4) averaged 97%, which was significantly higher ($P < 0.05$) than that of all other treatments. The survival in the 0.2 mg/l and 0.4 mg/l (70% and 73%, respectively) concentrations of CuSO_4 were significantly greater ($P < 0.05$) than higher

dose treatments, but were not significantly different from each other ($P > 0.05$). Treatments containing 0.6, 0.8, and 1.0-mg/l copper sulfate demonstrated a dramatic decrease in prawn survival, which averaged 30, 7, and 0%, respectively. Regression analysis of the data predicted 48-hour LC₅₀ for copper sulfate to be 0.46 mg/l. Since recommended application rates for use of copper sulfate as an algaecide are 1.0 mg/l or more for water with alkalinities of 100 mg/l, copper sulfate treatments are not recommended for use in prawn production ponds.

A comparison of production and growth characteristics of largemouth bass, *Micropterus salmoides*, and mean-mouth bass, *M. salmoides* \times *M. dolomieu*. WILLIAM STILWELL*, BORIS GORMELSKY, SHAWN COYLE, DAVID YASHARIAN LEIGH ANNE BRIGH and JIM TIDWELL, Aquaculture Research Center, Kentucky State University, Frankfort, KY 40601.

A series of studies were conducted to evaluate means of producing and relative production characteristics of the hybrid black bass (*Micropterus salmoides* \times *M. dolomieu*), commonly known as the meanmouth bass. Study 1 compared the use of HCG, carp pituitary extract, and LHRH as spawning hormones. Female broodfish of both species responded best to HCG, while males responded best to carp pituitary extract. Study 2 compared the fertilization rates of largemouth eggs when exposed to smallmouth bass milt vs. largemouth bass milt. There was no significant difference in percent fertilization ($P > 0.05$), which averaged 21% overall. Study 3 compared fry survival through the period from hatch to swim-up. There was no significant difference ($P > 0.05$) between pure largemouth and hybrids in swim-up survival, which averaged 96.5%, overall. Study 4 compared feed-training success. Feed-training success, average weights and survival of largemouth or meanmouth hybrids were not significantly different ($P > 0.05$). Study 5 compared first year growth when stocked at 1.25 and 2.5 fish/l. After 77 days there was no significant difference ($P > 0.05$) in meanmouth or largemouth bass in terms of average weights or percent survival with at the low density but at the higher density largemouth were significantly larger ($P < 0.05$).

The effect of tank coloration on survival, metamorphosis rate, weight, and time to reach the post larvae stage in freshwater prawn, *Macrobrachium rosenbergii*. DAVID YASHARIAN*, SHAWN COYLE, AARON VANARNUM, LEIGH ANN BRIGHT, WILLIAM STILLWELL and JIM TIDWELL, Aquaculture Research Center, Kentucky State University Frankfort, KY 40601.

Freshwater prawn culture has become increasingly popular in temperate regions of the United States and includes three distinct phases of production: hatchery, nursery, and pond growout. The hatchery phase is technically demanding and labor intensive. As a result, seed stock-costs can represent >50% of the total production costs. To facilitate continued growth of the prawn industry the development of efficient hatchery production technologies will be required. It has been shown that color could have

a significant effect on the feeding behavior, growth and survival of aquatic invertebrates. In larval prawn culture, dark tanks (black or blue) are most commonly used. The purpose of this study was to evaluate the effect of tank coloration on survival, metamorphosis rate, weight, and time required to reach the post larvae (PL) stage. Newly hatched prawn larvae were stocked into eighteen 16 l plastic rearing tanks at a density of 30/l. The tank colors evaluated were red, black, white, blue, green, and yellow, with three replicates per treatment. Larval prawn were fed brine shrimp nauplii (*Artemia franciscana*) twice daily; beginning at day six a supplemental egg custard diet was also fed in addition to the brine shrimp nauplii. All feed rates were based on a published feed table. Tank temperature was maintained between 28–30°C and dissolved oxygen was maintained with constant aeration. Water quality was maintained using a common biofilter, and all critical parameters were monitored regularly. On day 25 all larvae had metamorphosed into PL and the entire study was harvested. Harvest data indicated that larval tank color had no significant impact ($P > 0.05$) on the final PL size or days required to reach metamorphosis. Total survival was significantly higher ($P < 0.05$) in the red and green treatments (84% and 78%, respectively) than the white and blue treatments, (56% and 44%, respectively). Survival in the yellow and black treatments was intermediate (71% and 71%, respectively) and did not differ significantly from other treatments ($P > 0.05$). These data indicate that tank color plays a significant role in the survival of larval prawn reared in recirculating systems. Based on this data red and green appear to be the optimal. White or blue tanks are not suggested.

GIS analysis of prime farmland fragmentation in two Central Kentucky counties. DEMETRIO P. ZOURARAKIS, Kentucky Division of Conservation, Department for Natural Resources, Frankfort, KY 40601.

Central Kentucky's prime farmland is facing unprecedented development pressure. Mercer and Boyle counties are an example of this trend. In and around Danville and Harrodsburg, agricultural producers are participating in programs such as PACE (Purchase of Agricultural Conservation Easements) and Agricultural Districts Program to protect land from development. Prioritization of expenditures is based on whether applications fall within or near the high risk/high quality areas. Based on the Cooperative Soil Survey data, 1:250,000 scale, digital STATSGO (USDA-NRCS) data, the combined area of the two counties contains 56,13 and 31% in mapping units containing 0–20, 20–60 and 60–100% of prime farmland, respectively. On the other hand, the 1:12,000 scale digital SSURGO (USDA-NRCS) data indicate that 29 and 71% of the land area represents prime farmland (all prime farmland + prime farmland with limitations) and no prime farmland, respectively. Sixty-five percent of the 24,300 hectares in prime farmland are still uncommitted (not protected and not used for residential, commercial or transportation) in contrast with 75% of the 80,500 hectares not under prime

farmland. Based on population density data obtained analyzing the 2000 U.S. Population Census, 42 and 40% of all prime farmland and of all non-prime farmland, respectively, are under the high population density class (upper 20%) versus 29 and 19% under the low population density class (lower 20%).

CELLULAR & MOLECULAR BIOLOGY

Association of a genetic variant of the T β R-I gene with bladder carcinomas. CHAD R. JACKSON*, NATALIE SINGER, EMINA ATIKOVIC, LARRY DOUGLASS, JULIA H. CARTER and TAIPING CHEN, Molecular Biology Lab, Wood Hudson Cancer Research Laboratory, Newport, KY 41071.

Bladder cancer is the fourth leading cancer incidence among men and the ninth among women in recent US cancer statistics 2002. The possible involvement of transforming growth factor- β signaling pathway (TGF- β) in bladder tumorigenesis has been indicated by the observation that elevated local and circulating TGF- β are associated with cancer invasion, progression, and metastasis. A genetic variant of TGF- β type I receptor (T β R-I), a key element in the TGF- β signaling pathway, has been found to be associated with clear renal cell carcinomas in our recent study. In order to find out whether this genetic variant of T β R-I will be associated with bladder cancer in addition to clear cell renal carcinoma, we have analyzed 26 transitional cell carcinomas of the bladder. Using polymerase chain reaction and single strand conformation polymorphism (PCR-SSCP), 12 of 26 (46%) bladder transitional carcinomas from paraffin-embedded tissue showed the genetic variant allele of intron 7 in the T β R-I gene, which is significantly higher than 32% genetic variant carriers among non-tumor controls. No somatic mutations have been found among all nine exons of the T β R-I gene. Our results suggest that T β R-I may be required in bladder tumorigenesis. The high frequency of the genetic variant of the T β R-I gene in bladder tumors indicates that the variant may provide a selective advantage during cancer development and progression. Further investigation of the involvement of this genetic variant of the T β R-I gene in bladder tumorigenesis is warranted.

CHEMISTRY

The synthesis and metal-complexing ability of a novel polyether. STACEY STREETER*, JANE BARCELO and BRUCE BRANAN, Department of Chemistry and Physics, Asbury College, Wilmore, KY 40390.

A new tri-ether has been synthesized in our laboratory in which the three oxygen atoms are strategically oriented for metal complexation. The compound was made via Diels-Alder cycloaddition of benzene with furan, followed by KMnO₄ hydroxylation of the alkene, and finally by Williamson etherification of the diol using methyl iodide. X-ray crystallographic analysis of the diol has established the *syn*—nature of the oxygen atoms. The synthetic sequence,

analysis findings, and the results of metal-complexation studies are presented.

GEOGRAPHY

The problem of forest block delineation in Kentucky: An approximation using raster analysis with GIS. DEMETRIO P. ZOURARAKIS* and MARC EVANS, Kentucky Department for Natural Resources, Frankfort, KY 40601 and Kentucky State Nature Preserves Commission, Frankfort, KY 40601.

One land cover classification (1992 National Land Cover Data Set—United States Geological Survey) and one plant community classification (GAP National Project) are readily available for Kentucky. This paper presents the results of a first approximation to the study of forest fragmentation of pivotal importance in the context of forest preservation and management. Utilizing the 2002 GAP Project draft vegetation map, road-less areas were determined, potentially containing forest patches that possess certain properties of interest, such as threshold values for forest patch metrics (area; percentage of inclusions; area: perimeter ratio; etc.). Raster analysis was conducted using a GIS to delineate continuous, forested regions. A total of 1,892 contiguous forested areas were delineated, ranging in sizes from 360 to 26,300 hectares. Sixty percent of the forest blocks had a surface area of 970 hectares or less. Nine percent of the forest blocks were larger than 10,000 acres. Internal openings of 56 acres or less were found in 90% of the forest blocks. However, the percentage of area in internal openings ranged from less than 0.1 to 23.5%; 93% of the blocks had internal opening areas of 10% or less. Area: perimeter ratio values ranged from 110:1 to 2,130:1 with 75% falling below the 725:1 value.

COMPUTER SCIENCE

Computer simulation of cell growth regulation in vitro. ANDREA LAYNE*, STEPHEN HUNT, ROBERT L. MOOSE, Jr. and RAYMOND E. SICARD, Division of Mathematics & Natural Sciences and School of Osteopathic Medicine, Pikeville College, Pikeville, KY 41501.

Expansion of a cell population in culture reflects interplay between growth-promoting and growth-inhibiting influences. Stimulation of cell proliferation (passage through the cell cycle; e.g., $G_1 \rightarrow S$ transition) generally is produced by serum while suppression of proliferation (e.g., leaving cell cycle for G_0 state) is caused by contact-mediated events or release of inhibitory factors. We have developed a model that simulates cell growth under general culture conditions. The model combines discrete-event simulation to describe temporal behavior, with 2-dimensional cellular automata to describe spatial behavior; it uses *Sim + /Simpack* for simulation support and a cellular automata package known as *CAEL* as the basis for spatial dynamics. Additionally, the model implementation (under Linux) provides an optional graphical display that allows the user to observe both temporal and spatial aspects during simulation runs. The model assumes a one-

day cell cycle time, requires a decision to continue in cell cycle or enter G_0 shortly after division, and begins with a high probability of remaining in cell cycle initially. The model adjusts the probability of continued cell proliferation based on the number of contacts from neighboring cells. For example, when eight neighboring cells make contact with a cell, that cell enters G_0 irreversibly. In addition, this model includes production of an inhibitor by cells in G_0 which acts to reduce the probability of other cells to remain in cell cycle. The influence of this inhibitor decays with distance from the source. This model simulates cell growth in culture as it might be influenced by inhibition through cell contact and the production of a diffusible inhibitor of proliferation. Experiments are in progress to reconcile parameters of the model with actual behavior of rodent fibroblasts in culture.

GEOLOGY

Geologic map of the southern half of the Pond Run 7.5 minute quadrangle, Scioto County, Ohio. ERIC D. ROBINSON* and CHARLES E. MASON, Department of Physical Sciences, Morehead State University, Morehead, KY 40351.

The purpose of this study was to map the bedrock geology of the southern half of the Pond Run 7.5' Quadrangle. The study area is located in southernmost Ohio, along the Ohio River. The majority of Pond Run mapped is found within Shawnee State Forest. This area has dendritic drainage, moderate relief (750 feet), and is heavily vegetated. Bedrock geology of Pond Run is composed of siliciclastic rocks of Devonian and Mississippian age, which dip to the southeast at less than 1.0 degree per mile. Lithologic units encountered from oldest to youngest are: Cleveland Member of the Ohio Shale (Devonian), Berea Sandstone/Bedford Shale undifferentiated (Devonian), Sunbury Shale (Mississippian), Cuyahoga Formation (Mississippian), and the lower part of the Logan Formation (Mississippian). Additionally, Quaternary alluvial deposits were mapped along the Ohio River. The primary field methodology was the utilization of a Brunton Multi-Navigational System with a built in altimeter to record position of contacts and their elevations. The area was structurally contoured on the base of the Sunbury Shale. No faults or other structural features were noted. Pond Run contains significant slumping in its southwestern corner, especially where the Bedford Shale thickens in the Berea/Bedford interval. Additional slumping occurs in the base of the Cuyahoga Formation where the Henley Shale Member thickens. Slumping is generally triggered by deforestation or over-steepening of these slopes. Key discoveries in this mapping project include neptunian dikes in the Ohio Shale and the first zonal conodont assemblage (*Upper duplicita Zone*) from the Sunbury Shale. These discoveries exemplify the need for detailed geologic mapping in the field at a 1:24,000 scale.

The Rockford Limestone in the Appalachian Basin. BRIAN PATRICK CAMPBELL* and CHARLES E. MA-

SON, Department of Physical Sciences, Morehead State University, Morehead, KY 40351.

Sandberg, Mason, and Work (2001) reported a thin dolomitic unit in the base of the Borden / Cuyahoga formations as being equivalent to the Rockford Limestone of the Illinois Basin. The purpose of this study was to compare samples of the proposed Rockford Limestone equivalent from the Appalachian Basin to samples and the published literature on the type Rockford Limestone of the Illinois Basin. Five sample locations were used in this study: one in the Illinois Basin, and four in the Appalachian Basin. Comparisons were made of the following: thickness, lithology, stratigraphic position, macro/microfossils, relative age, and depositional environment. The thickness of the proposed Rockford in the Appalachian Basin ranges from 2 to 37 cm, whereas in the Illinois Basin it ranges from 85 cm in southern Indiana up to 10 meters in parts of northwestern Indiana. The lithologies compared favorably, as both ranged from a dolomitic to biolomicrite. Additionally, both units occur in the exact same stratigraphic position. The macroinvertebrate fauna was essentially identical with respect to diversity, relative abundance, and mode of preservation between all the localities studied. The only microfossils examined were conodonts because of their biostratigraphic utility. The conodont fauna recovered from the Ohio samples, Brightman Cemetery (Kentucky), and the Clarksville (Indiana) site all belonged to the same upper Kinderhookian conodont zone (*isosticha*-Upper *crenulata*), which is characteristic of the lower Rockford. Those collected from the State Route 801 (Kentucky) site were from the lower Ossagean (Lower *typicus*) conodont zone. This site equates to the "upper Rockford rubby or nodular zone" found in the base of the New Providence Shale Member of the Borden Formation in the type Rockford area. Thus, the samples from the Appalachian Basin are relative age equivalents of the Rockford Limestone in the Illinois Basin. All samples examined appear to be deposited predominantly as a combination of both hemipelagic and distal storm deposits. The source of carbonate storm deposits would have been from the craton to the west, which accounts for the units eastward thinning. Due to the favorable comparison of all aspects compared between these two units, the consensus of this report is that the dolomitic units found in the Appalachian Basin study area are Rockford Limestone equivalents.

Diversity and abundance of the macroinvertebrates found in the dysaerobic Cave Run Lake fauna (Lower Mississippian) Morehead, Kentucky. CHARLES E. MASON* and TED ADAMS, Department of Physical Sciences, Morehead State University, Morehead, KY 40351.

This fauna is located from 11/2 to 21/2 meters above the base of the Nancy Member of the Borden Formation. All 250 kilograms of material processed was collected from the mile post 135/I-64 section, which is located approximately 2 miles west of the Morehead exit, in a roadcut along the west bound lanes. Bulk samples were col-

lected from the study interval, then taken to the lab and placed in ovens to remove the water. Samples were then weighed out into 5 kilogram amounts, placed in buckets, and immersed in kerosene for 24 hours. The kerosene was then decanted off and the sample placed in water. Samples set in water until disaggregation takes place or up to 24 hours. The disaggregated sample was then washed through a number 20 sieve. All material caught on the sieve was dried and weighted. This residue was then picked for macroinvertebrates using a binocular microscope. Picked macroinvertebrates were then identified and counted. A total of 600 identifiable specimens were recovered, equaling 2.4 specimens per each kilogram of sample run. Twenty-two separate species were identified in the Cave Run Lake Faunal Project—eleven were mollusks. Gastropods were the most diverse group with 6 species, followed by brachiopods with 5 species and cephalopods with 4 species. A medium spired gastropod was most abundant with 220 specimens out of 600 total and gastropods overall composed nearly ¾ of the total abundance (363/600). Thus, the Cave Run Lake fauna is dominated by mollusks in both diversity, 11/22 species, and abundance, 423/600 specimens.

GEOGRAPHY

Kentucky's climate during the Civil War. GLEN CONNER, Kentucky State Climatologist Emeritus, Department of Geography and Geology, Western Kentucky University, Bowling Green, KY, 42101.

Weather data exist from Springdale and Pine Grove in Kentucky from the Civil War years of 1861–1865. Additional data exist from Newport from 1863–1865. Five other locations have one or two of the Civil War years. These stations are too few and five years are too short to make conclusions about the entire Commonwealth. But they define climate in the important central portion of Kentucky during an important period. These stations were part of the Smithsonian weather observation network that was established in 1847. Climate data and information from the longer term Kentucky stations used in this study come from two sources. The Smithsonian observers made daily observations and submitted the Smithsonian Institute Register of Meteorological Observation form after the end of each month. At Pine Grove, a weather journal of Dr. Samuel D. Martin provides daily observations from 1862–1868 and monthly data from 1858–1868. The Smithsonian data are part of the recently digitized pre-1896 Kentucky climate data set. These data reveal an extreme drought from May through December 1862 and another from April 1863 through July 1864. The droughts created water shortages and reduced the agricultural production of food for people and livestock. Foraging by military forces further reduced that food supply. The war induced shortage of labor, the confiscation of horses and mules during the military incursions, and other uncertainties added to the miseries of the drought. The weather observer records provide an important source for both climate and its impacts on Civil War Kentucky.

HEALTH SCIENCES

School lunch program study Part I: Food selections of sixth-grade students. MARTHA A. MARLETTTE* and SUSAN B. TEMPLETON, Human Nutrition Research, Kentucky State University, Frankfort, KY 40601.

Many Kentucky children have poor diets which lead to obesity and health risks. While over three-fourths of Kentucky students have inadequate intakes of fruits and vegetables, 88% of middle schools offer students "junk food" via vending machines or cafeteria sales. Sample food trays were purchased ($n = 5$) to establish daily portion sizes and selections available in three middle school cafeterias. Individual food trays of sixth-graders were photographed before and after lunch were eaten to identify foods selected and consumed by the students. Nutritionist V was used to calculate nutrient content of food items offered. A 100-point Nutrient Density Index (NDI) was computed for each food item using % Recommended Daily Allowance (RDA) for 10 nutrients, protein, vitamin A, vitamin C, iron, calcium, vitamin E, thiamin, riboflavin, niacin, and folate compared to %RDA for energy. SPSS 10 for Windows was used for statistical analysis. Fifty-one percent of the 369 students were female; 81% were white. Items most selected were: milk (NDI = 61), 294 times, mostly chocolate-flavored 1%; potatoes (NDI = 51), 137 times (mostly fries); fresh fruit (NDI = 57), 103 times; and salad (NDI = 77), 71 times. Pizza (NDI = 40) was most popular entree, selected 67 times. Thirty-one percent of sixth-graders purchased extras: chips (61 students), non-carbonated soft drinks (43 students), and sweet snacks (41 students), with an average NDI of 5. This suggests that while most school lunch offerings were nutritious, lower nutrient density items were available to and popular with these adolescents. Higher NDI items were less popular within most food groups.

School lunch program study Part II: Plate waste of sixth-grade students. ESUGHANI OKONNY*, SUSAN TEMPLETON and MARTHA MARLETTTE, Human Nutrition Research, Kentucky State University, Frankfort, KY 40601.

Being overweight is increasingly prevalent among Kentucky's children, yet most have diets low in fruits and vegetables. We collected lunch tray leftovers from 369 6th grade students in three Frankfort middle school cafeterias. Leftover portions for each item on the tray were weighed and recorded. Nutrient content of the plate waste was calculated using Nutritionist V and aggregated by student. SPSS 10 was used for statistical analysis. The most wasted foods were fruits (38% of initial portion weight was left) and vegetables (33%). Fresh apple waste was 73%, while only 23% of applesauce was uneaten. Meats had 19% wastage; mixed dishes (pizza, pasta with meat sauce, sandwiches, and casseroles) had 18% wastage. Grains waste (bread, rice, taco shells, etc.) was 14%. Students left 16% of their milk; 7% of cheese (used as a topping) was wasted. The a la carte items purchased in the cafeteria were wasted the least: chips (3%); non-carbonated soft drinks (6%)

and snack cakes/cookies (6%). An average of 160 kcal of dietary energy was wasted by students who had purchased a la carte items with their school lunch, while 125 kcal was wasted by those who did not purchase additional items ($P < 0.05$). These results suggest that wasted food reduced energy intakes, especially in those who did not buy a la carte items. Preparation method influenced waste for fruits (canned wasted less than fresh, $P < 0.05$) and potatoes (mashed wasted less than boiled or fries, $P < 0.01$). Student comments indicated taste was a major factor in food waste.

School lunch program study Part III: Nutrient intakes of sixth-grade students. SUSAN B. TEMPLETON* and MARTHA A. MARLETTTE, Human Nutrition Research, Kentucky State University, Frankfort, KY 40601.

Federal standards require school lunches provide 33% of Recommended Daily Allowance (RDA) for energy, protein, vitamin A, vitamin C, iron and calcium and limit fat content. Food trays of 369 sixth-graders at three middle schools were photographed before students ate, and collected after they finished. We estimated initial portions by comparing weighed portions from sample trays purchased from the cafeterias. We weighed and subtracted the leftovers to calculate each student's actual consumption. Nutritionist V was used for nutrient analysis and SPSS 10 for statistical analysis. Students consumed only 25% of their energy RDA (boys = 2475 kcal, and girls = 2162 kcal) at lunch. Based on a 12%-30%-58% energy distribution between protein, fat, and carbohydrates, protein provided 98% of recommended lunch-time calories, but carbohydrate and fat provided only 69% and 81% of the lunch-time calorie needed. Students had adequate lunch-time intakes of vitamin A (135% RDA), and vitamin C (42% RDA). Calcium intake was lower for female than for male sixth-graders, 26% and 34% RDA, respectively; iron intake of females (21% RDA) was notably inadequate. Lunch-time intake was low for vitamin E, thiamin, and folate (13%, 19%, and 28% RDA, respectively). Riboflavin and fiber intakes were 30% RDA. Nearly one-third of sixth-graders purchased extras along with their lunch; these soft drinks, chips, snack cakes, etc., contributed 39% of their calorie intake but very few important nutrients. Eliminating junk food options and enhancing taste appeal of school lunch items are essential strategies for increasing vitamins, iron and calcium in school lunches.

Arsenic in well water from eastern Kentucky and surrounding counties. JOHN G. SHIBER, Division of Math and Science, Prestonsburg Community College, Prestonsburg, KY 41653.

One hundred and four domestic tap water samples, chiefly from private wells in 8 eastern KY counties and 7 counties in bordering states, were analyzed for arsenic. Of the 96 samples originating from wells, 24 had below 1 ppb arsenic (0.50–0.93), while 3 had over the Maximum Contamination Level of 10 ppb: 11.10 ppb, Floyd County, KY; 19.70 ppb, Kanawha County, WV; and 81.50 ppb, Johnson

County, KY. Nineteen samples had from 1.02 ppb to 9.63 ppb arsenic. Four of the samples were from homes that had participated in a similar study during spring 2001, in which their water, analyzed at a local commercial lab by Plasma Emission Spectroscopy, had had elevated levels (10.0–33.9 ppb) of arsenic. Analysis in the present study, which found no detectable arsenic in the water of the same homes, was by the more sensitive Hydride Generation/Atomic Absorption Spectrometry at the University of North Carolina's Environmental Quality Institute. More comprehensive work concerning arsenic in private well water of the region is recommended, because so many people still rely on it for their needs. This should include the most sensitive methods of analysis for this element. Arsenic was present in over half the well samples analyzed here, and even very low concentrations are considered by many scientists to be unacceptable for human health. The elevated arsenic in groundwater recently reported for this region by the Kentucky Geological Survey gives further justification for more rigorous research along these lines.

PHYSIOLOGY & BIOCHEMISTRY

Histochemical and biochemical studies on the tentacle secretion of male bristlenose catfish (*Ancistrus* sp.). N. VIRGINIA LINTECUM* and HONG Y. YAN, T.H. Morgan School of Biological Sciences, University of Kentucky, Lexington, KY 40506.

Bristlenose catfish (*Ancistrus* sp.) get their common name from their distinguishing morphological feature, fleshy tentacles which grow from their snout. The tentacles of adult males are larger and more widely spread over the snout than those of females or juveniles, and their function has been a mystery. Since the tentacles have taste buds distributed on them, it has been suggested that they are used for chemoreception. Recently a hypothesis has been proposed to suggest that tentacles are larval mimics used by males to convince females that they are good fathers. This theory is untested, but arises from the fact that *Ancistrus* are one of the few groups of fish that exhibit solely paternal care in which male *Ancistrus* build nests in caves and crevices, and then guard the embryos and newly-hatched larvae. Histological sections and histochemical studies on the snout tentacles revealing thousands of goblet cells in the epithelial layer of *Ancistrus* tentacles prompted our hypothesis that male *Ancistrus* provide nutrients to their young via secretions from their tentacles. Histochemical staining revealed that goblet cell contents are likely to be high-energy glycoproteins. Electrophoresis and glycoprotein detection methods are used to further delineate the chemical composition of the secretion. Results of histochemistry and electrophoresis will be discussed before further investigation is conducted to examine male-juvenile interactions and behavioral and olfactory reactions of juveniles and females to the male tentacle secretion.

Patterns of energy allocation in immunochallenged and testosterone-treated white-footed mice (*Peromyscus leu-*

copus). MANINDER K. VIRK*, RICHARD BLALOCK, MARSHALL WELCH and TERRY L. DERTING, Department of Biological Sciences, Murray State University, Murray, KY 42071.

The cost of mounting an immune response was studied in normal and testosterone-treated male white-footed mice (*Peromyscus leucopus*). We tested the null hypotheses that: 1) there is no change in metabolic rate during an immunochallenge and 2) there is no change in energy allocation to other systems during an immunochallenge. We established four groups of animals: control, testosterone-treated, immunochallenged, and immunochallenged plus testosterone. Injections of testosterone propionate were given for 10 days to elevate the level of testosterone. Immunochallenged animals were injected with sheep red blood cells (SRBC) and phytohemagglutination (PHA) to challenge the humoral and cell mediated branches of the immune system, respectively. To test our first hypothesis we determined the daily metabolic rate (DMR) and the resting metabolic rate (RMR) of each animal. To test our second hypothesis we measured the masses of the body organs. There was a significant increase in RMR in the immunochallenged animals, but no difference in DMR among groups. Thus, our first hypothesis was partially supported. Immunochallenge had no significant effect on the masses of intestinal and vital organs, but was associated with a significant increase in the masses of the reproductive organs. We, therefore, rejected our second hypothesis. Our findings indicated that there was a significant cost associated with mounting an immune response, as indicated by the increase in RMR. In addition, there was an increase in energy allocation to the reproductive organs. Thus, under good conditions there was no trade-off in energy use for immunity and reproduction.

SCIENCE EDUCATION

Impacts of a revised introductory biology curriculum on attitudes and learning of biology majors. TERRY L. DERTING*, CLAIRE FULLER and WILLIAM SPENCER, Department of Biological Sciences, Murray State University, Murray, KY 42071.

In an effort to improve student learning and success within the biology major, we developed and implemented a new introductory biology curriculum supported by an NSF CCLI-A&I grant. The curriculum focuses on active inquiry as a means of helping students develop a more in-depth and meaningful understanding of biological concepts. Two new courses to be taken upon entry into the curriculum have been implemented. One, Biological Inquiry and Analysis, focuses on understanding of biology as a process of inquiry. The other, The Cellular Basis of Life, introduces students to basic concepts in cellular biology. Pre/Post assessment of student content knowledge, analytical skills, confidence in specific science-related skills, and attitudes toward science has been conducted in the introductory courses each semester since 2000. Students have shown a significant improvement in content knowledge and analytical skills. Initial data indicate that the im-

provement in content knowledge, but not analytical skills, has been retained as students enter upper level courses. Assessment of student attitudes has shown that students enter the curriculum with a positive view of science. It appears to be difficult to further enhance the positive attitudes, but relatively easy to diminish those attitudes. After completing the two new introductory courses, students showed a highly significant increase in writing and critiquing ideas, using analytical skills, solving problems scientifically, and applying biological concepts and skills to everyday life. Although our results are preliminary, we believe that the new curriculum is helping students gain the skills necessary to succeed in upper level biology courses.

ZOOLOGY

Feeding specializations in heterochronic morphs (*Triturus alpestris*, Amphibia, Caudata). MATHIEU DEN-OËL¹*, ROBERT SCABETSBERGER² and PIERRE JOLY^{3,1} Chargé de Recherches du FNRS, Laboratory of Fish and Amphibian Ethology, Department of Life Sciences, University of Liège, 4020 Liège, Belgium. Present address: Department of Biological Sciences, Murray State University, Murray, KY 42071, USA, e-mail: *Mathieu.Denoel@ulg.ac.be*; ² Zoological Institute, University of Salzburg, 5020 Salzburg, Austria; ³ Laboratory of Ecology of Fluvial Hydroystems, Claude Bernard University of Lyon, 69622 Villeurbanne, France.

Polymorphisms are suspected to reduce competition among conspecifics in heterogeneous environments by allowing differential resource use. However, the adaptive significance of alternative morphs has been poorly documented. The aim of this study was to test this hypothesis by comparing diets of syntopic heterochronic morphs (paedomorphs and metamorphs) in the Alpine newt, *Triturus alpestris*, in three European alpine lakes. Feeding performance was also tested in the laboratory. The two morphs differ in the functional morphology of their feeding apparatus. Only paedomorphs are able to expel water behind the mouth during prey suction through gill slits. We observed a substantial trophic differentiation between morphs consistently in all lakes. Paedomorphs primarily preyed on plankton whereas metamorphs foraged on terrestrial invertebrates that fell to the water surface. Laboratory observations were consistent with field patterns. In paedomorphs, prey capture success rate was better than in metamorphs when foraging on aquatic crustaceans, but was less successful when foraging on terrestrial invertebrates caught at the water surface. By reducing competition, resource partitioning contributes to the coexistence of the alternative morphs in lakes devoid of vertebrate competitors and predators. Food diversity is thus an important factor favoring the evolutionary maintenance of facultative paedomorphosis in natural populations.

Assessment of the terrestrial small mammal fauna of Terrapin Creek State Nature Preserve, Graves County, KY. KELLY E. SOMERLOT* and TERRY L. DERT-

ING, Department of Biological Sciences, Murray State University, Murray, KY 42071.

The Terrapin Creek State Nature Preserve (TCSNP) in Graves County, KY, was established in 1992 by the Kentucky State Nature Preserves Commission to protect the unique assemblages of plants and animals found in the Terrapin Creek Wetland Complex. Trapping of small terrestrial mammals was conducted throughout eight tract areas of TCSNP using Sherman Live traps and pitfall arrays. A total of 10,890 trap nights were conducted over a 1-year period, at 6-week intervals, to inventory the species composition and small mammal communities of the area. A total of 1,382 animals were recorded, representing 14 small mammal species. The species list determined from the trapping effort was found to be comparable with a predicted species occurrence list generated from the Kentucky Gap Analysis Project database. Diversity, dominance, and evenness indices revealed that a high level of diversity and unique communities of small mammals are contained within the preserve. The white-footed mouse (*Peromyscus leucopus*) and marsh rice rat (*Oryzomys palustris*) were the dominant species on seven out of the eight tract areas. Tract analysis using polar ordination techniques revealed that most of the eight tracts at TCSNP support unique communities of small mammals. The inventory provides new information for the state's documentation of the area, including the confirmation of nine additional species. We predict that the high biodiversity at TCSNP will persist if management practices that maintain the vegetation and habitat heterogeneity are implemented.

The effects of testosterone on the immune system in white-footed mice (*Peromyscus leucopus*). RICHARD BLALOCK*, MARSHALL WELCH, MANINDER VIRK and TERRY DERTING, Department of Biological Sciences, Murray State University, Murray, KY 42071.

Testosterone is believed to be immunosuppressive in mammals. Recent research suggests, however, that testosterone may cause redistribution of leukocytes rather an actual reduction in leukocyte numbers. One hormone known to induce immunoredistribution is corticosterone. To investigate the effects of testosterone, we tested the null hypotheses that: 1) testosterone has no effect on corticosterone level and 2) testosterone has no effect on the distribution of leukocytes. We established four groups of adult male white-footed mice (*Peromyscus leucopus*): 1) control, 2) testosterone-treated, 3) immunochallenged, and 4) testosterone-treated and immunochallenged. Testosterone injections were given to mice for 10 days. The immunochallenged mice were treated with sheep red blood cells (SRBC) and phytohemagglutinin (PHA). To determine if immunoredistribution occurred blood samples were taken from the heart and the retro-orbital sinus. There was no significant redistribution of leukocytes in any group of mice; however, the reaction to PHA was much greater in the control mice than the testosterone treated mice. Total white blood cell counts revealed no

significant differences between the control group and testosterone treated group. Corticosterone levels were lowered by the testosterone injections so redistribution could not have occurred due to corticosterone. We concluded that testosterone does not raise corticosterone levels and is not related to immunoredistribution. Testosterone did lower the activity of leukocytes.

Geographic area in relation to accuracy assessment of predicted vertebrate distributions. TERRY L. DERTING*, ADAM SMITH and HOWARD WHITEMAN, Department of Biological Sciences, Murray State University, Murray, KY 42071.

To assess the accuracy of the 361 predicted species' distributions produced through the KY-GAP, we used three levels of assessment that differed from each other through the geographic size of the areas used for assessment. First, relatively small validation areas were assessed by measuring the omission error, commission error, and agreement of species' checklists for natural areas around the state and species lists compiled along the North American Breeding Bird Survey (BBS) routes in Kentucky with our predicted species' distributions for those areas. Next, we conducted an assessment at the physiographic province level, using omission error and agreement rates within each of the eight provinces that occur in Kentucky. Lastly, we conducted an assessment based on independent locational records for the entire state, again calculating omission error and agreement rate for each species. The

results of the assessments using checklists for small validation areas and point locations for the entire state indicated a high level of accuracy ($\geq 80\%$) for most taxonomic groups. The majority of errors were attributable to modeling of aquatic species. For the physiographic province assessment, agreement rates were very high and varied little among the provinces. The elevated degree of accuracy within this assessment was attributed to the tremendously large areas of the provinces. Based on our assessment results, we believe that most predicted distributions from KY-GAP have a high level of accuracy. Nevertheless, users should become familiar with the accuracy of each species' distribution map(s) prior to their use.

Are there costs to being dominant? CASSIE JOBE, GUION JOHNSTONE and, MAGGIE PARKER, Department of Biology, Transylvania University, Lexington, KY 40508.

In this study, we investigated the effect of dominance on aggression during feeding, and how it ultimately relates to growth in juvenile blockheads (*Steatocranus casuarius*). We conducted feeding trials on group of fish, observing patterns of aggression and feeding. Changes in length and weight for each fish were recorded before and after each trial. The data we collected indicate that dominant fish feed less and are more aggressive than subordinate fish that had greater gains in length and weight. This supports our hypothesis that there are costs associated with being dominant.

Some Abstracts Submitted from the 2002 Meeting of the Kentucky Junior Academy of Science

Edited by Robert J. Barney

The mission of the Kentucky Academy of Science (KAS) is to encourage scientific research, to promote the diffusion of scientific knowledge, and to unify the scientific interests of the Commonwealth of Kentucky. These goals are accomplished, in part, through programs sponsored and encouraged by the Kentucky Junior Academy of Science.

The abstracts below are among those submitted by participants in the 2002 Junior Academy meeting. Having met at least the minimum standards established by KAS for student work, they are included here in the hope that they will encourage their authors to go beyond these initial efforts and, continuing work in science, develop into the scientists of tomorrow.

BEHAVIORAL & SOCIAL SCIENCES

Pharmaceutical patient assistance programs: do doctors help their patients utilize them effectively? MEGHAN NOLAN, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

Many poor patients do not qualify for Medicaid and need financial aid to pay for their medications. They can get the financial aid they need via Patient Assistance Programs (PAPs). These programs, used by doctors, take extra time to use, but are necessary to benefit indigent patients. Many questions need to be asked to see if these programs are really working. The purpose of sending a questionnaire on this topic was to gain an insight on whether doctors are using PAPs to their full potential. When doctors were given the survey, they likely knew what PAPs are, but it was suspected that only about half of the doctors already had the PAPs in their office. The percentage of indigent patients who are eligible for PAPs out of the total number of patients in the office will be about one in ten. The results from the survey are as follows. All 25 of the doctors said that they had heard of the PAPs. Twenty-two of the doctors wrote that they do have a certain type of PAP in their office, whereas three of the doctors do not. Eighty-eight percent of doctors do have PAPs in their office, which is a lot more than the hypothesized 50%. Out of the doctors that do use PAPs, 16 have been using them for 2 years or more, 6 have been using them from 1 to 2 years, and 1 just started using them last year. The three doctors who do not use the PAPs listed reasons they do not: time, money, and uncertainty of how to use the programs. Those three doctors also said they did not intend

to implement PAPs into their office after taking the survey. The average percent of indigent patients out of the total office patients was 3.87%, well below the expected 10%. The overall results were encouraging because doctors are using the PAPs more than we expected. After carefully analyzing the results, it was concluded that almost all doctors seem to be using PAPs to the best of their abilities.

Neuroplasticity and linguistic processings as a function of hearing aid use. DANIELLE HACETOGLU, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

Communication plays an essential role in our everyday life. It is with communication that we are able to interact with the rest of society and the outside world. People converse with one another with language, especially spoken language. Spoken language is made up of talking and listening. People listen by hearing what is said. Hearing is a very important part of interaction. If someone is not able to hear or hear well, it is important for him or her to seek treatment. A doctor's first resort in treating a patient with hearing loss is a hearing aid. A hearing aid is a small electronic device that fits inside and around the back of the ear and amplifies sounds, making it easier to hear and enabling people to communicate easily. This particular experiment questioned whether one's hearing can change over a period of time after hearing loss exists. The purpose of this experiment was to see if brainwave latency and response (e.g., areas of activation) would change as a function of hearing aid use over time. In addition, if there was a change, how long did the change take and if that correlated with adjustment to hearing aid use (e.g., if the subject perceived sounds/words better over time). It was predicted that one would see a change in the latency of the neural response, e.g., brainwaves, to sounds as a function of hearing aid use over time. The experiment was completed with the use of the electroencephalograph, and the data collected on the electroencephalogram were used to see if there was any sort of significant change found. Change did not occur over the 9 months that tests were run.

The effect of information and threat on conformity. DAVID MILLER, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

A questionnaire was written to evaluate a person's position on America going to war, their perceived level of threat to America, the level of their conformity, and their level of awareness of current issues. The war was merely a tool for getting the opinions of many people on a com-

mon subject that involved threat to the group. Participants were interviewed by three people asking questions about their position on America going to war. The interviewers, assuming views opposite those of the participants, asked five prewritten questions framed to give the correct impression and gave prewritten arguments to try to get participants to conform to their opinion. The participants' reactions were then rated on an objective scale and their scores averaged to yield their conformity level. It was believed that higher levels of perceived threat or lower levels of awareness would make a participant more likely to conform readily. However, when the results were analyzed it was found that the data supported the null hypothesis: no relationship existed between awareness and conformity or perceived threat and conformity.

Effect of modes of recall and leading questions on the creation of false memories of an event. SHANNON TURNERY, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

The purpose of this experiment was to determine whether different forms of recalling memories and leading questions have any effect on false memory creation. A real-time video of a car crash was shown to volunteers. Immediately after viewing the event, some subjects were asked to describe it in written or oral form. A third group did no formal recall. Testing with leading, moderately leading, or neutral questions followed. Overall, those who did no verbal recall scored highest on individual items, with percentages ranging from 70% to 96%. Those who orally recounted the event had the lowest accuracy, with correct responses only 32% to 50% of the time. There was one exception to the "no recall" group performing best. On that item, those engaged in the written recall scored highest. In the analysis involving leading questions, trends were obvious. With questions that did not have precisely defined answers but rather required estimates, the leading questions were more effective in creating false memories. Other questions that asked for yes-or-no answers and expressed doubt, led subjects to believe that the answer to the item was "no" when in fact it was "yes." Curiously, some leading questions produced an effect opposite to the intended effect, but further research would be necessary to understand this phenomenon. All results seem to indicate that verbally recounting events and responding to leading questions enhance the likelihood of producing false memories.

BIOLOGICAL SCIENCES

Characterization of the "cold shock" response of *Escherichia coli*. AKINWANDE A. LALUDE, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

Bacteria demonstrate a response to reduced temperature (cold shock), which is characterized by an alteration in gene expression. The focus of this experiment was to demonstrate this response in *Escherichia coli* and to determine (1) whether there was a threshold temperature for the response and (2) were there changes in protein

expression that had not been identified previously. *E. coli* were grown at 42°C and rapidly transferred to either 25°C or 15°C to evaluate the cold shock response over a period of 20 hours. Cross-sectional isolation was done and after 35, 95, 485, 1205, and 2475 minutes the bacteria were harvested by centrifugation and lysed by sonication to recover the cytoplasmic proteins. The quantity of protein recovered was determined and 30 micrograms of each sample were loaded on a graduated 4–20% polyacrylamide denaturing gel and electrophoresed. The gel was stained and the banding in each lane was assessed to determine the protein expression pattern in each group. The results indicate that there was not a threshold for this response (i.e., it was observed at both temperatures but to various degrees) and that the expression response was typical of those noted previously in this organism.

Demonstration of KSP-32 protein as myo-inositol oxygenase by cloning and expression—a protein linked to diabetes. K. NATHAN PARTHASARATHY, duPont Manual High School, 120 West Lee Street, Louisville, KY 40207.

A search for an unknown protein in gene bank of the NCBI prompted the analysis of a rare protein called KSP32. This protein is exclusively present in human kidneys and possibly linked in the disease process of diabetes. Preliminary analysis suggests that KSP32 may function as an enzyme as inositol oxygenase (MIOX). To demonstrate this hypothesis DNA from rat kidney was isolated and used to produce the enzyme in bacteria by molecular cloning methods. An efficient *Escherichia coli* expression system for the production of rat myo-inositol oxygenase (MIOX) protein has been constructed. Rat kidney MIOX cDNA was cloned into expression vectors, pRSET A, B, and C. After the plasmid was introduced into *E. coli*, this bacterial culture was induced with isopropyl thio-galactopyranoside (IPTG). The recombinant MIOX protein was purified from bacterial extracts. Passing it onto a nickel column purified the clarified supernatant. The purity of the fractions was tested on 12% SDS-Electrophoresis technique (PAGE). The fractions eluted with 40 mM imidazole buffer showed a relatively pure MIOX protein band of ca. 32,000 in molecular weight. Cloning and expressing of rat MIOX in bacteria offers an excellent source of its unlimited supply. Functional enzyme assay for inositol oxygenase is being carried out. If it produces a functional enzyme, it can be used for its protein structure and antibody production. Large-scale production and structural studies will help design new drugs targeting this vital kidney protein. My project has successfully produced rat myo-inositol oxygenase protein in pRSET vectors A because it was in frame with the expression-cloning segment. This bacterial system is capable of producing an unlimited supply in a short time for further research on experimental diabetes and hypoxic conditions.

Experimenting with the functionalism of the knee. MICHAEL S. HAWORTH, duPont Manual High School, 120 West Lee Street, Louisville, KY 40206.

The ACL (anterior cruciate ligament) is in the middle of the knee. It contracts, expands, and holds the joining knee bones together. In addition, it is one of the biggest causes of athlete injury. After years of research and analysis, it was found that girls injure their ACLs more often than boys. The point of this paper was to investigate and experiment on girls and boys to try to find out why the difference. In short, it can be said that many hypotheses have been said to answer that same question. One is biomechanical. So somehow, the inside muscles and movement affect it. Another reason is the bone structure. Three is hormonal. Four is environmental. In addition, five is protection. By protection, it means that somehow and for some reason men and women are not supported with protection like a knee brace. On the other hand, women do not use them as often as men do. Surveys were organized and the physical structure of the knee was examined. Data were collected into chart format, and many different facts were observed. From other data (data of the structure and length of the ACL), it was found that most women have a weaker and narrower notch surrounding the ACL, which may actually prove to make women more fragile and prone to the injury.

The correlation between heart rate recovery and track mile times. CHRISTINA M. HAMM, duPont Manual High School, 120 West Lee Street, Louisville, KY 40241.

As a person engages in regular aerobic exercise, the heart, lungs, and muscles become more efficient at using oxygen. The heart pumps more blood with each stroke, the lung capacity of each inhalation increases, and the muscle fibers extract more oxygen from the blood. The training effect on the heart is obvious when heart rates are compared between long-distance runners and sedentary individuals. The athlete will have a lower heart rate at rest and during light jogging, for example, than the non-athlete. For this experiment, heart rates were used to see if there was a correlation between them and high school runners' 1-mile track time. If there is a correlation of heart rates and fitness levels (endurance athletes need to have high fitness levels) then there is also a correlation between 1-mile track times and heart rates. In this experiment, the subject's pulse was taken before a 400 m sprint, then immediately after one, and then again 1 minute after the sprint, 2 minutes, and 3 minutes. Then, after 24 hours recovery, the subject was timed for 1 mile on a track. A trend was found in all the data, which directly correlates with the mile times. It is easy to see that a higher percent of recovery correlates with a faster mile time. However, due to the lack of a significant volume of data, there was not one true formula to predict a mile time based on their heart rate recovery.

Distinguishing differences between grayscale values and color hues. ANDREA MASON, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

The human eye is a very complicated organ. Several features translate visual stimuli into nerve impulses, in-

cluding visual receptor cells called rods and cones. Rods detect the presence of a stimulus and its brightness, whereas cones detect color stimuli. The purpose of this experiment is to discover at what point the difference between two shades of gray or chromatic hues produce a difference in stimulation of receptors that results in the perception of a boundary line. PowerPoint presentations containing areas of different grayscale and color values were created. Subjects viewed these presentations wearing prefabricated glasses, which isolated areas of the retina of high rod or high cone concentration, as well as under normal conditions with no retinal isolation. The minimum discrimination difference, MDD, was defined to quantify the minimum difference in shades of gray or color hues that a subject could recognize. This experiment showed that subjects were better at distinguishing the differences in shades near the middle gray region of the traditional grayscale (DN 128–121) than the extremes of the grayscale, white (DN 4–0) and black (DN 255–219). In addition, the ability to distinguish colors and differences in the grayscale decreased as smaller and smaller parts of the retina were isolated. As retina isolation increased, the average MDD increased and/or the proportion of subjects not answering increased, indicating that the ability to distinguish differences in the shades decreased. Rod isolation did not improve the ability to distinguish differences in the grayscale, and cone isolation did not improve the ability to distinguish color differences. Reduction in the intensity of light reaching the retina when rod and cone vision glasses were worn may have contributed to this result.

BOTANY

The effects of light wavelength on phototropism in *Phaseolus vulgaris* and *Zea mays*. ADAM WEIS, duPont Manual High School, 120 West Lee Street, Louisville KY 40299.

The purpose of this experiment was to determine how variations in light wavelength affect the growth and curvature towards a light source over time, and if the changes in growth or curvature caused by light wavelength differ between C3 and C4 photosynthetic plants. The height and angle towards light source of 36 plants, equally distributed amongst light colors and plant species—*Phaseolus vulgaris* (C3 photosynthesis) and *Zea mays* (C4 photosynthesis)—were measured daily for 8 days, and the average growth and curvature was calculated each day. The hypothesis was that blue or violet light would stimulate growth and curvature most efficiently, that the relative growth and curvature at different wavelengths would differ little, and that the curvature-to-growth ratio would be constant regardless of species or filtered light color. The results suggested that blue light was the strongest and yellow or red light the weakest growth and curvature stimulant for both *P. vulgaris* and *Z. mays*, but most apparent differences in growth and curvature stimulation were not significant. The relative growth and curvature trends over light wavelength did not significantly differ between the C3 and C4 plants,

and the curvature-to-growth ratio was found to be nearly constant. If this project were continued or expanded, more light-specific filters would be utilized, and plant species differing in chemical pathways other than photosynthesis would be examined.

Effects of microwave radiation on the growth and germination of *Brassica rapa*. BRETT M. THOMPSON, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

This experiment focused on determining the effects of low-power microwaves at 2.0 GHz frequency on germination and growth of *Brassica rapa*, or Wisconsin Fast Plants of the Brassicaceae. The experiment was performed to predict what would happen when the world begins using microwaves reflected off the sun's rays for energy. It was estimated that there would be no effect due to the low power of the microwaves. To perform this experiment, 120 Fast Plants were used. Sixty of these were the control and were not exposed to any microwaves and the other 60 were exposed to microwaves at a frequency of 2.0 GHz. All of the Fast Plants began as seeds in the experiment, allowing for analysis of germination percentage. Heights in centimeters were measured each day for 2 weeks. The plants were kept apart but in the same growth chamber, allowing for the same humidity, temperature, and measured light intensity. Eighteen of 60, or 30%, of the non-microwave plants germinated; 37 of 60, or 61.67%, of the microwave plants germinated. In addition, the microwave plants had an average height 1.3 cm greater than that of the non-microwave plants. Two 2-sample *t*-tests were performed to check for significance in germination and height data and both rejected the null hypothesis, giving evidence supporting that microwaves do indeed affect the growth and germination of Fast Plants, which goes against the stated hypothesis. Mass measurements were also taken on Day 10 and a *t*-Test was performed, resulting in a p-value of 0.11, which is too low of a significance level.

Extraction and application of expansin to heat-inactivated stems of cucumber seedlings. LISA SOPER, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41042.

It has been observed by many that when substances with a low pH (<5.5) are applied to growing cell walls, the cell will elongate. Expansin is a protein naturally found in cells that also helps with expansion. Expansins are unique to the plant world. They can cause two types of expansion. The only one observed in this experiment was creep: the long-term, irreversible extension of cell walls. Expansin was extracted from a bunch of celery (Cosgrove 2001). This involved blending, chilling, and filtering the celery, followed by centrifugation, which resulted with a pellet of expansin. Cucumber seedlings were grown. At the early stage they were cut at the soil line and cotyledons were removed. The stem was then secured between an apparatus formed with two ring stands, one of which

held up a rotary motion sensor connected to an IMAC. On the other ring stand was a clip, securing fishing line that extended from the two stands with alligator clamps separating them and a 40 g weight on the other end. The stem was secured between the alligator clamps. The fishing line lay on the rotary motion sensor, sensing the length difference, which was recorded and graphed. These graphs demonstrated that when expansin is applied to cell walls, the walls would elongate. When buffer of pH 4 is added, the walls expand very little and quickly come to a constant length. Similar results were obtained when gibberellic acid was added.

The effect of abscisic acid on plant growth under drought conditions. HUY LE, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

Scientists are constantly researching new ways of improving plants. A good deal of research is focused on increasing drought tolerance. One way is to use a chemical that could induce stomatal closure and thereby increase the tolerance level. The purpose of this research is to subject plants to great water stress (drought) and then observe what happens when abscisic acid (ABA) is injected into them. It was hypothesized that plants with ABA injection would be more tolerant of drought. The results showed that the ABA plants do indeed have more tolerance. However, after the *t*-test was run, the data were found to be insignificant. It was concluded that ABA does not increase drought tolerance. It is recommended that the research be repeated using a higher quantity of ABA, higher ABA solution concentration, longer experimentation time, and that measurements of root growth be recorded.

Vitamin therapy for root crown gall disease: plant pathology of *Agrobacterium tumefaciens*. WHITNEY HARROD, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

In this experiment root crown gall disease was introduced to Marigold tomato plants, Rutgers tomato plants, and tobacco variety KY 160. The experiment was to infect plants with root crown gall disease and treat them using vitamin therapy. It was hypothesized that the use of selected vitamins would cure or decrease the gall size formed on the three plants and improve their visual appearance. The procedures used included attempting to grow from seeds a combined total of 300 tobacco and tomato plants. However, not all of them successfully germinated. One hundred and eighty plants were grown for 4 weeks. They were then infected by making two small slits in the base of each plant and injecting the bacterium *Agrobacterium tumefaciens*. In the experiment, four plants were chosen in each set so averages would be more accurate. Variables were soft gel capsules of vitamin A and liquid vitamins E, B, and C. For Rutgers tomatoes, four plants were given vitamin A at 5 ml twice weekly for 6 weeks. This was repeated for each vitamin and was defined as group one. Group 2 was the same plants with the

same vitamin but given at 10 ml twice weekly for 6 weeks. Plants were categorized by color, height, gall size, and overall visual appearance. The plants were 6 weeks old when vitamin therapy began. Vitamin therapy did not decrease the size of the galls. However, vitamin A increased plant height while vitamin B decreased plant health by wilting and turning leaves yellow. West Vitamins E and C had no effect on the plant's appearance.

CHEMISTRY

Effect of titanium dioxide on the photocatalytic destruction of Procion MX Bright Blue 404 dye. SARAH FIEGER, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

The purpose of this project is to find what effect the amount of titanium dioxide present in an acid reactive dye solution has on the rate of its degradation by UV-C light. This problem was studied by preparing 0.05 g/l Procion Bright Blue dye to serve as simulated wastewater. An absorbance curve showed that 610 nm was a good wavelength to quantitate the dye concentrations. A known amount of the solution along with a measured amount of titanium dioxide were then placed under a UV-C light and the absorbance was measured using a spectrophotometer. The absorbances were then graphed and the rate of degradation was found. This was done with additions of 0.015 g, 0.010 g, and 0.005 g of titanium dioxide. The waste solutions were efficiently degraded, with the rates varying from 1.14 to 0.0921 ppm/min. The rate of degradation increased with the amount of titanium dioxide but not in a linear fashion. Through this process, it was found that increased amounts of titanium dioxide acted as a catalyst and increased the rate at which the color from the wastewater was eliminated. Without both UV-C light and titanium dioxide, the degradation of Procion Bright Blue dye proceeded very slowly if at all.

Evaluating the potential of freshwater Winogradsky columns to generate electric potential differences. MONICA SUMME, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

Recently there has been much publicity about electricity produced from marine sediments. The purpose of this experiment was to discover whether a freshwater Winogradsky column could also generate electricity. Winogradsky columns were constructed with 2-liter bottles; electrodes were inserted at 5 cm intervals. When these proved unsuccessful, new columns were set up using standard chromatography tubes and electrodes placed at 2.5 cm intervals. One contained only pond mud and water; others were enriched with cellulose, Na_2SO_4 , and CaCO_3 . After 12 days, potential differences were detected between electrodes at various levels in the column. All electrode pairs registered potential differences, most of which remained relatively constant over time. Enriched columns yielded greater voltages than the control, presumably because more bacteria grew in them. Voltages ranged from a few

millivolts to over a volt. Currents from about 1 to 120 μA were observed.

Crevice corrosion mitigation. HARISH SRINIVASAN, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

Crevice corrosion in the gaskets of flanges is a major problem for piping systems that causes billions of dollars worth of damage yearly. Crevice corrosion occurs by the ionization of metal atoms resulting in their leaving the bulk metal. The formation of metal ions is called polarization. The purpose of this research was to find a method to mitigate crevice corrosion. A rubber o-ring with a groove on the bottom with an embedded platinum wire was placed on a stainless steel plate and firmly held in place with a flange and clamps. The well formed by the ring was filled with a 3.5% NaCl aqueous solution. A reference electrode was placed near the crevice. Control corrosion tests were run, as were corrosion tests with the application of a -400 mV potential. The process was repeated with 1% FeCl_3 . The results of the corrosion tests showed a decrease in polarization resistance with the application of the potential, indicating an increase in corrosion. Tests run prior to and after the application of a potential showed a decrease in polarization resistance in the tests after applications. Corrosion was least when the working electrode was left alone. The negative potential may have caused some particles such as chlorine ions to change polarity, aggravating the corrosion. Excess electrons may have also caused the bonding of hydrogen ions and the dissolution of the gaseous film on the cathodic surface of the metal, exposing the metal to the electrolyte and allowing for more corrosion.

Hydrogen evolution for portable fuel cells. JANE HU, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

Presently, common sources of energy, such as fossil fuels, are limited in access, non-renewable, and detrimental to the environment. Hydrogen, however, is a plentiful, possibly renewable, and clean fuel with a by-product of only water. Because of its characteristics, development of the method of hydrogen generation could be valuable. The purpose of this experiment was to determine if pure and sufficient hydrogen could be generated to power portable fuel cell devices by a simple method: the combination of natural organic acid and metal in an aqueous solution. An apparatus for gas collection was set up. Widely available and cheap metals and acids were tested: acetic acid, formic acid, zinc, nickel, and iron (three metals were selected by their varying reduction potential). After adding the metals and acids in an aqueous solution, evolution of hydrogen was recorded every 10 minutes for 90 minutes. The equipment was then left for 48 hours, after which the final evolution of each metal-acid combination was recorded. Gas chromatography tests were performed. Five out of the six combinations produced hydrogen, evolving at steady rates. Iron and formic acid evolved the most

hydrogen, creating 620 cc. By comparing all data, it was concluded that formic acid was more reactive than acetic acid and iron was the most reactive metal, and all hydrogen generated was more than 99% pure. Calculations indicated that collected hydrogen was practical and suited to fuel electrical machinery, such as CD players or even satellites, revolutionizing energy sources and industry.

COMPUTER SCIENCE & MATHEMATICS

Feasibility of using passive repeaters in long-range wireless computer data transmission. ANDREW GODFREY, Boyle County High School, 332 North Danville By-Pass, Danville, KY 40422.

Devices known as passive repeaters are mentioned on the Internet as a method to bend 802.11b wireless data signals. The purpose of this experiment was two-fold: to determine if the idea of a passive repeater is feasible and which design(s) of passive repeaters are most effective. Two setups were used: one indoors and one outdoors. In both setups, signals were bent around objects. Each computer sent 100 pings (packets of 32 bytes of data that are sent from and returned to a computer to measure connection distance and strength) and used a third-party software program to log various aspects of signal performance. The parabolic-type passive repeater provided the shortest (and therefore fastest) ping times and maintained a stronger wireless signal. The parabolic passive repeater proved to provide signal levels at or above what is acceptable for outdoor metropolitan use. These indicate that a passive repeater is effective and feasible.

Nurse Internet Scheduler: using the Internet to solve the problem of nurse shortages. SONIA NIJHAWAN, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

In light of the growing nurse shortage experienced by hospitals all over the world, a plan was offered to create a nurse scheduling system database that allows registered nurses to fill and bid on available hospital hours using the Internet. Numerous factors influence both the supply of registered nurses and the demand for nursing services. The Nurse Internet Scheduler (NIS), as it will be called, addresses all of these factors and encompasses them into a system that extracts the most from the nurses we already have. In essence, instead of trying to produce more nurses, the system takes advantage of the current nurse workforce. With the intention of gaining a better understanding of hospitals and their current problems, all of the hospitals in Louisville were researched. The detailed requirements of the scheduler were defined, its design was created, its databases were developed, security measures were added, and, finally, touchups were added before releasing the final product. The creation of the system proved to be a highly challenging task. Many programming languages were used, including Microsoft Access, SQL, Visual Basic, Visual Interdev, and Microsoft FrontPage. By matching hospital requests with nurse availability, the NIS should provide a constant supply of nurses to the hospitals in

need. It schedules nurses on a micro basis: not day by day, but shift by shift. The scheduler will be used as a tool for saving the lives of patients, whose present healthcare quality is in high danger. After a local start, use of the nurse database will steadily expand to become a worldwide product: allowing nurse transactions to be made internationally.

Mathematics is not yet ready for such problems: Collatz Conjecture rationalized. ROBERT BRACO, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

Collatz Conjecture is a famous problem in number theory that deals with a classic recursive function. When any natural number is iterated through the function, it is suspected that it will converge to one. It was first conceived by Lothar Collatz in 1937 and, despite many attempts, has remained unproven for over 75 years. Because it is reminiscent of a chaotic system, its importance to the field of cryptography is great and its many ties to other branches of mathematics make it essential to prove. Several new results on the problem were found that are expected to lead to a formal proof within the next year. The data were used to derive a probability function that can accurately predict the divisibility of any number that is iterated through Collatz Function. Linear number sets were iterated through Collatz Function and the number of iterations it takes for those sets to return to less than their starting value was determined. Patterns in the results gave structure to the complex sets of numbers and set up a partial proof that has great potential of turning into a complete proof. A method called linear decomposition was used to find further structure in the data. As a result, several formulas were derived that will predict the trajectory of any given number set as it is iterated through Collatz Function. Finally, the set was found that had the most chaotic results when it is iterated through the function and a formula was derived to determine the number of dual-growth iterations that will occur before the number begins its convergence to one.

EARTH & SPACE SCIENCE

Effect of microgravity on seed germination and amylase content of *Phaseolus vulgaris*. KATHLEEN ALBERS and EMILY STOVER, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

Microgravity is a condition in which objects do not experience the full force of gravity and are therefore under different influences than they normally experience on Earth. Experimentation in this area is beneficial for the advancing of the space program, especially the possibility of humans living in space for extended periods. By growing plants such as *Glycine max* (soybean) in microgravity, the feasibility of a long-term food and oxygen source was investigated. The purpose of this experiment was to build a bioreactor that would simulate a microgravity environment for bean seeds in order to study their germination pattern and amylase content compared to that of beans

placed in normal Earth conditions. The bioreactor was run for extended periods, during which measurements of mass and radicle length were taken daily. Later, gel electrophoresis was performed to differentiate between amylase content in beans subjected to different conditions. A germination control group in a culture dish on damp paper toweling germinated and grew normally and displayed evident, active alpha amylase. The seeds under microgravity conditions germinated while the seeds in identical conditions with the exception of a full force of gravity did not. The results from electrophoreses showed that amylase production was not hindered in any of the experimental seeds.

A retrospective analysis of tornados in Kentucky: 1950–2002. NICHOLAS REYNOLDS, duPont Manual High School, 120 West Lee Street, Louisville KY 40208.

A tornado is a rotating column of air ranging in width from a few yards to more than a mile and whirling at destructively high speeds, usually accompanied by a funnel-shaped downward extension of a cumulonimbus cloud. Each year in Kentucky, tornadoes cost millions of dollars in unprotected damage. The goals of the study were to find the amount of money the state should be spending each year to cover the cost of tornado damage for the state in relation to probability of occurrence. The secondary goal was to devise a mathematical equation to determine the amount of damage that should be incurred from a tornado of a given F-speed. The data were obtained from the mainframe file kytor and run from 1950 to September 2002. Appropriate steps were taken to decode and analyze the data. Averages were taken, numbers totaled and classified, and then a T-test was run on the data to test for significance. All data, with the exception of that for F-4 and F-5 tornadoes, were significant. The insignificance can be attributed to there being only 20 tornadoes of such strength in the state in the past 53 years. The equation $-7.43277 \times 10^6 \cdot x^4 + 9.28235 \times 10^7 \cdot x^3 + -3.78833 \times 10^8 \cdot x^2 + 4.5711 \times 10^8 \cdot x + 2.31239 \times 10^8$ was also found to represent the relationship between F-speed and property damage for the state. The conclusion was that the state should expect to pay around 7.5 million dollars in tornado insurance per year.

ENGINEERING

Minimizing tissue damage with needle point design variation. BORIS D. CHERNOMORDIK, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

This study dealt with finding a needle point design that can cause minimal tissue damage and trauma and have optimal penetration capability and optimal usefulness in any possible application. Quantitative tests were conducted, but needle point designs were also analyzed beyond the results of the quantitative tests. Six custom needle point designs, the "Blunt Point," "Finger Point," "Double Cut" point, "Straight Angle" point, "Small Radius Cut" point, and the "Two Radii" point, were manufactured with a dremel with a cylindrical grinding stone, and stone files

for deburring. A Chatillon LRX Material Testing Machine was used to puncture a polyurethane film at 100mm/min for each needle point design. Nxygen Software captured the resistance. The results were analyzed using the Tukey HSD method. The "Small Radius Cut" design and the "Two Radii" design produced the least maximum penetration resistances, with the exception of the "Standard Point." The latter was the commercially manufactured needle, with had features that could not have been reproduced for the custom designs used in this study. The "Straight Angle" design was the analogue custom design for the "Standard Point." This study found the "Two Radii" design favorable for other aspects as well, including its sharp point with a short needle length and its rounded heel for reduced tissue drag. This study concludes that the "Two Radii" point design has the potential to perform better than the "Standard Point" design if the difference in quality of manufacturing were eliminated. This research does not answer for the exact effects on needle performance of the various aspects of commercial manufacturing of needles.

Competition for the hydraulic car lift. STEPHEN A. AGE and JUSTIN B. LEIBOWITZ, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

The hydraulic car lift is the most popular device for lifting cars. However, it is the most expensive device, ranging between \$35,000 and \$50,000. The purpose of the project was to design a device that would be able to compete with the hydraulic lift while costing much less. The goal was design a device using a CADD program. Ideas were first hand-sketched and analyzed. If problems arose early, a new idea was created and analyzed. The final idea was drawn with a CADD program. The main components of the idea were a worm gear, motor, and two columns. The worm gear and motor were mounted to one another above the loading area for the car. Drive shafts were connected to the worm gear. By doing this, the power from the worm gear was transferred to the rest of the lifting components. Prices were obtained for the final idea and calculations were done to see how much the device would cost, weigh, and lift. The final idea was within the goals set earlier in the project and was deemed the Age-Lee Car Lift. Therefore, the hypothesis/goal was partially met; a device moderately capable of competing with the hydraulic lift was created. It was not fully capable of competing because it could not lift as much weight.

Designing and fabricating a piezoelectrically actuated miniature peristaltic pump. ARTHUR J. KIM, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

A linear piezopump was designed to overcome the disadvantages of the disc-type piezopump built by NASA. The pump, based on the operational principle of ultrasonic motor, uses two piezoelectric bodies, of which the actuators cause the formation of a traveling wave when voltage is applied. The amplitude of the wave was mea-

sured using a laser vibrometer to observe whether the pump successfully created a traveling wave. The inability to pump liquid raised a suspicion that the damping effect of the liquid was a major problem of the piezopump. The data showed that there was no position at which the flexural wave had an amplitude of zero, which indicated that the pump successfully created a traveling wave. In addition, the fact that the average amplitude of the wave decreased from 0.995 to 0.1 indicated that the damping effect of the liquid was the major cause to the low pumping efficiency of the NASA piezopump. The contributions of this project are twofold. First, a piezopump in linear shape was built with a successfully generated traveling wave. Therefore, this project has demonstrated the possibility of linear piezopump in development and use that is more effective. Secondly, the damping effect of liquid, which seems to have caused the NASA rotary piezopump to produce a low discharge pressure, was discovered to have a significant effect on the amplitude of the wave. This discovery will further help the researchers who are currently designing a pump using the microscopic deformations of piezoelectric materials.

ENVIRONMENTAL SCIENCE

A comparison of soil arthropods in lawns with or without herbicides. RUTH WHITE, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

This study tried to determine if there was a significant difference between arthropods in the upper stratum of herbicide-treated and untreated lawns. The hypothesis for this study was that the lawns with herbicides (the variable) would have less diversity in plant life, and therefore have less in the way of arthropod diversity and population than those lawns without herbicides (the control). Five samples were taken from each of eight lawns, four lawns having been treated in the past year with herbicides, and the four lawns not having herbicide treatment. Chi-square tests were used to find the level of significance for the variables. The results did not support the hypothesis and the null hypothesis of there being no significant difference between the arthropod type diversity and population was retained. Though the results did not support the hypothesis, the winter season and the cold weather were not favorable conditions for this study and a warm season (summer or spring) experiment would be considered for results that are more accurate. More samples of soil from more lawns of each classification would also provide results that are more accurate. In observing the data collected, certain arthropods appeared to thrive better within the herbicide treated lawns. These considerations could be subjects of further study.

The analysis of heavy metals in plant and soil samples. CHINADU OUT, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

Heavy metal content of plant and soil samples in the Louisville, Kentucky, area was determined. The plant samples were *Helianthus tuberosus*—A1, A1F(flowers); *Po-*

pulus sp.—A2; *Solanum dulcamara*—A3; *Artemisia annua*—A4; *Chenopodium ambrosioides*—A5; *Taxus* sp.—C1; *Taraxacum* sp.—C2; *Camassia* sp.—C3; *Daucus carota*—C4; and *Chamaesyce vermiculata*—C5. The samples were treated with nitric acid to mineralize their metal content. Liquid chromatography with a mixed resin column was used for the simultaneous determination of the following metal ions: lead, copper, cadmium, manganese, cobalt, zinc, iron and nickel. Two eluent systems containing pyridine-2, 6-dicarboxylate (PDCA) and oxalic acid were used as the mobile phase. Postcolumn derivatization with pyridine (PAR) and absorption of light at 530 nm was used for detection and quantitation. The metals in the samples were identified by matching their retention times to those of standards analyzed under identical conditions. The amount of the metals in the samples was obtained from a calibration graph. Copper, zinc and manganese were found in all the samples (including the flowers). Cadmium was found in all samples except A5. Lead was not found in any plant sample but was found in one soil sample. The results of this study showed that plants do indeed absorb some but not all metals from the soil in which they are planted and that liquid chromatography is an effective way of determining target metal amounts.

The effectiveness of rain-gardens in nitrate and runoff reduction. MARGUERITE BLIGNAUT, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

The purpose of this work was to test the ability of rain-gardens to filter out nitrate and their ability to reduce the amount of runoff. This experiment was done using two rain-gardens (A and B) that were made of layers of topsoil, gravel/sand, and clay. A control was set up which replaced the gravel and sand with more clay. Ten liters of tap water, simulating rainwater, were first poured over the rain-gardens and control, and the nitrate levels were measured along with the volumes of the runoff and transported water. The runoff was essentially nitrate-free, but the water that was transported through the soils to the simulated water table had substantial nitrate (60–110 mg/l), indicating nitrate was being removed from the soil. In three subsequent runs, 10 liters of nitrate-enriched water (22 mg/l) were poured over the rain-gardens and the control. Nitrate levels and volumes were again measured. The rain-gardens and the control added more nitrates to the water that was transported down through the soil, sometimes to levels as much as three times the original level. These "water table" levels ranged from about 50 to 90 mg/l, and there was usually not a great difference between control and rain-gardens, although the control levels were slightly lower. The amount of nitrate in the runoff stayed consistent for all of the runs (~25 mg/l). The control consistently had the least amount of runoff, opposite of what had been hypothesized.

Biodeterioration of granite, limestone, and marble due to *Phormidium* growth. SARAH MARCUS, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

The role of the cyanobacterium *Phormidium* in the deterioration of granite, limestone, and marble was examined. It has been suggested that the presence of cyanobacteria can lead to the damaging of stone surfaces, especially those surfaces that have been exposed to physical or chemical weathering. Samples of granite, limestone, and marble were obtained. Some of these samples were weathered by freezing and thawing when dry or wet. Other samples were weathered by having an acidic solution dripped onto their surface to simulate acid rain. These samples, along with a control, were placed into beakers where *Phormidium* was grown on the surface. Similar samples were also placed into beakers with only water to serve as a control. After 5 weeks, images of all samples were compared under magnification to the images taken before the *Phormidium* was grown. The *Phormidium* grew the most on samples that had been weathered. For granite, it grew best on the sample that was frozen when dry, and on limestone and marble it grew best on the sample that was acid-exposed. Damage to the surface was evident on the samples on which *Phormidium* was grown, especially on those having the most *Phormidium*. These results show that *Phormidium* does contribute to the deterioration of granite, limestone, and marble.

A study of toxic air compounds in the Rubbertown area, Louisville, Kentucky. ALISSA DOS SANTOS, CHELSEA MOTTER, and AUBRIE TOSSMANN, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

This study attempted to determine whether or not there is an increasing trend in the release of 1,3-butadiene, acrylonitrile, and chloroprene in Rubbertown, West Louisville, Kentucky. These volatile organic compounds have been determined to be potentially carcinogenic. West Louisville is home to several rubber manufacturers, and the testing sites in that area have been determined to be potential maximum impact sites. It was hypothesized that there would be a general increase in concentration based on amplified industrial activity in the Rubbertown area as a result of increasing demand over time. After air samples were collected at the Ralph Avenue/Campground Road and Louisville Police Firearms Facility, the concentrations (parts per billion) were compared to the control site at the University of Louisville Shelby Campus. This data supported the hypothesis, as there was a general increase in concentrations in 2002 as compared to 2000 and 2001. Variances in the gas chromatograph, which was used to extract the concentrations from the air samples, weather, and the factories' rubber production could have altered the data. One alternative in the production of synthetic rubber is whole process of greenization of low-cost synthetic rubber. This is a new type of low-cost synthetic rubber without any pollutant. Continued research would further support the findings and lead to conclusions that are more specific.

Allotment of phytoplankton that can escape the detrimental effects of ultraviolet radiation: a simulation. DA-

VID TRUONG, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

Phytoplankton are plant-like organisms drifting near the surface of bodies of water. High-intensity ultraviolet radiation, such as that of the sun, is extremely detrimental to life. Lacking protective ultraviolet-absorbing layers, which higher forms of marine life possess, all forms of phytoplankton are highly sensitive to ultraviolet radiation, specifically UV-B radiation, because it decreases photosynthetic activity. Because they form the basis of the marine food chain on which zooplankton and all other organisms of the marine ecosystem depend upon for sustenance, there is a concern that, due to pollution and global warming, through increased UV-B irradiance penetrating the ocean surface, phytoplankton communities will be harmed; therefore altering the dynamics of marine ecosystems. This experiment's purpose was to discover the depth at which phytoplankton must swim to escape these harmful effects. A 10-foot PVC pipe was filled with salt water, with the same salinity level as ocean water, a foot at a time up to 9 feet. A black light was placed on top of the PVC pipe and blankets and towels were draped over the top to prevent other sources of light from entering. Every foot below what would be sea level, readings were taken to determine the intensity of light at that level. After making calculations, a regression line, or curve, of best fit was found to determine the exact depth at which there would be zero absorption of ultraviolet radiation.

Air filters: expensive vs. inexpensive. CAMPBELL RIGHTMEYER, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

This project focuses on reducing the NO_x from vehicle exhaust using different air filters. It was hypothesized that a clean, more expensive air filter would best reduce the NO_x levels. Comparisons were made in this project between two brands of air filters (Valvoline and Pennzoil) and the cleanliness of the filters (clean, partially dirty, and dirty). Six conditions were tested at 700 and 2500 RPM on a 1999 Toyota Camry. Every condition was tested twice, with two different air filters, each with five trials, for 120 trials. NO_x levels were measured with a Bacharach Combustion Analyzer that required 60 seconds per test. All tests showed that a clean filter worked better than a dirty filter. A clean inexpensive filter worked better than even a partially dirty expensive filter. New research is needed to test the rate of decrease in efficiency of expensive and inexpensive air filters.

The effect of varying the dissolved oxygen levels in a stream on the levels of streptococci, chemical oxygen demand, and fecal coliform. VINITA BHASKAR, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

This study tried to determine if fecal coliform, streptococci bacteria, and chemical oxygen demand (COD) levels were affected by a change in dissolved oxygen (DO) levels. It was conducted in connection with similar studies

at the University of Louisville through cooperation with the Metropolitan Sewer District (MSD). Graphing each item with the rate of dissolved oxygen to observe if a pattern occurred was how the data analysis was completed. By viewing the contrast between the levels of each, a similar pattern developed with each reading. The data were collected at MSD Floyd's Fork Station, or Station 12. This site is known as an agricultural site due to the number of farms and, thus, the higher amount of discharged chemicals and fertilizers. Measures of different pollutants in the creek were derived, such as zinc, copper, and arsenic. The levels of dissolved oxygen were chosen for this study because DO is a good indicator of the presence of pollutants in water. Higher DO levels are known to maintain a low level of pollutants in general, but this study was done in order to find the specific effects that DO had on two bacteria, fecal coliform and streptococci. These bacteria are extremely harmful when in contact with humans, but levels of each are still present in our water supply. This study strove to find a correlation from the levels of dissolved oxygen and the levels of fecal coliform. The data analysis conducted proves that the levels of dissolved oxygen somewhat attribute to lower levels of fecal coliform and streptococci. For example, when the levels of dissolved oxygen were relatively low, the levels of fecal coliform and streptococci were fairly high. The chemical-oxygen demand percentage measurements also matched this pattern, reading high percentages as both fecal coliform and streptococci levels increased.

Potential of duckweed (*Lemna*) to remove chromium (VI) from water. ANDREA FRYE, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

It was hypothesized that duckweed (*Lemna*) would lower the concentration of chromium (VI) in spring water over time. The duckweed was gathered and placed into an aquarium. It grew for about 2 months. When the duckweed was ready, chromium-contaminated water was placed into four beakers. Once every week the chromium levels were checked to determine whether they were being lowered. Each week the chromium levels for the four samples were lower than those of the control (contaminated water without duckweed). The conclusion to this experiment was that duckweed is able to reduce the concentration of chromium (VI) over a 2-week period.

MICROBIOLOGY

The effect of common household cleaners on the growth of the yeast *Candida albicans* in the presence of calcium carbonate. JANE KIM and SUSHMA CHEN-NUBHOTLA, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

In this experiment, four common household cleaners (Tilex, Lysol, Ultra Clorox, and Scrubbing Bubbles) were tested on the growth of the yeast *Candida albicans* in the presence of calcium carbonate. It was hypothesized that calcium carbonate would have a positive effect on the growth of the yeast and have a buffering effect of the

cleaners. This was done by testing the cleaners at full strength on the yeast; then a 1% calcium carbonate solution was tested on the same amount of yeast. Since the cleaners were tested at full strength, the next step was to dilute them in a serial dilution with both water and the calcium carbonate solution. This was done to find the point at which the yeast would start growing and the cleaners would stop working. The yeast was tested at zero time and 15 minutes. The results were that calcium carbonate buffered the effect of Scrubbing Bubbles and Lysol on the growth of *C. albicans* only. Calcium carbonate had no effect with Tilex and Lysol when used on the yeast. In addition, calcium carbonate only stunted the effect of all four cleaners because at 15 minutes, the fungicides destroyed the yeast.

Temperature-UV dosage effects on survival of wild and UV-sensitive *Saccharomyces cerevisiae*. VERONICA RODRIGUEZ, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

The purpose of the experiment was to see how exposure to high and low temperatures affects the survival of wild and UV sensitive strains of the yeast *Saccharomyces cerevisiae*. Yeast organisms were diluted and exposed to UV-C light at intervals of time ranging from 0 to 180 seconds. The yeast were then exposed to temperatures of 4, 24, or 32°C and allowed to grow. Several runs were conducted and the results were recorded. The results of the experiment showed that in colonies exposed to low temperatures the detrimental effect of UV-C was decreased, while when exposed to high temperatures the detrimental effect was increased. Mutant colonies were sometimes observed and counted. High temperatures led to lower numbers of mutant colonies in wild *S. cerevisiae*, while both high and low temperatures resulted in higher numbers of mutant colonies in UV-sensitive *S. cerevisiae*.

Efficacy of a silver-ion compound in reducing *Escherichia coli* populations. ALEXANDER SULYEVICH, duPont Manual High School, 120 West Lee Street, Louisville, KY 40208.

The purpose of the experiment was to determine after what time interval the log CFU number of *Escherichia coli* on steel coupons not treated with the AgION silver ion formula would be significantly different from the number for untreated stainless steel. The AgION formula purportedly decreases microbes on a steel surface. A cell suspension of *E. coli* was created using the bacteria culture and trypticase soy broth with yeast extract incubated for 24 hours at 35°C. The number of viable cells was verified by plate count methods. Treated and untreated stainless steel coupons were inoculated with 0.5 mL of composite culture at ca. 1000 colony forming units (CFUs) per coupon. A 2-gram patty of raw, sterilized ground beef was placed on each coupon. All coupons were placed on trays and stored at 10°C. Samples of control and AgION-treated coupons were analyzed initially to determine the level of the inoculum and after 2, 4, 6, 24, and 48 hours. This

was done by placing ground beef patties in Stomacher bags, manually massaging them to dislodge bacteria, then using serial dilution and plate count methods to actually count the CFUs on the bacteria. T-tests revealed that the only time interval at which significant CFU decrease occurred between the treated and untreated coupons was the 48-hour interval ($P = 0.00692$).

Curcumin and genistin: potential natural agents for treatment of glioblastoma. DAVID MEIGOONI, Paul Laurence Dunbar High School, Lexington, KY 40513.

The effects of curcumin, genistin, and radiation on U87-MG glioblastoma cancer cells were measured. These effects were determined by the colony-forming assay in which the results were analyzed by comparing the survival fraction of the U87-MG glioblastoma cancer cells as a function of the dose of radiation, curcumin, and genistin. The curcumin had shown very strong cell kill property on glioblastoma. Genistin had also shown cell kill on the glioblastoma. The effect of the cell kill of genistin was increased when in combination with 2 μM of curcumin. Cell survival fractions of glioblastoma for radiation alone was measured and the SF2 was found to be ca. 0.5. Overall, genistin needed to be concentrated more than curcumin to achieve a good cell kill. The combination of radiation with genistin or curcumin remains to be explored.

PHYSICS

Comparison of film and thermoluminescent dosimetry technique for measurement in high dose gradient field. JOHN MEIGOONI, Henry Clay High School, 2100 Fontaine Road, Lexington, KY 40502.

Film and TLD are the two most common radiation detectors in radiology. Film is constructed of radiation sensitive emulsion coated on a thin layer of plastic. As radiation interacts with this sensitive material, it will change its chemical composition and hence darkens throughout processing of the film. The darkness of the film is related to the amount of radiation interacting with the film. Dosimetric characteristics of film and thermoluminescent dosimeters were compared for measurement in high dose gradient field. These comparisons were performed using two different x-ray machines: a megavoltage linear accelerator for high-energy x-ray and superficial x-ray machine for low energy beams. Relative film and TLD responses were evaluated as a function of beam energy and absorbed dose of radiation. The results of this investigation were used to determine the variation of dose distribution in a closed vicinity of a brachytherapy radiation source. The results indicate lower responses for both TLD and films with higher energy x-ray beams. However, the film response saturates for doses larger than 7 cGy at a low energy beam, while TLD does not show any threshold. Radiation distribution along the perpendicular direction from a 3-cm line source shows the clear advantage of film with high special resolution for measurement of radiation in rapidly changing radiation area.

The Newtonian physics of asymmetrical capacitive propulsion. EVAN FRANK, duPont Manual High School, 120 West Lee Street, Louisville, KY 40218.

Nearly all methods of producing thrust or motion require the use of some form of propellant or need moving parts. Using neither, a relatively new NASA patent (6,317,310) accomplishes this task by applying high DC voltage at low current to Asymmetrical Capacitor modules. The goal of this experiment was to construct and analyze a working Asymmetric Capacitor module to determine the acceleration, thrust, and efficiencies of the module; then the Asymmetrical Capacitor was compared to other forms of ion propulsion. A successful proof of concept model was made using the outline of the NASA patent, and experimentation was then conducted with the device suspended on a tethered pendulum. By observing the physical properties of the device, a linear test setup that allowed for time motion studies to observe the velocity and acceleration of the devices was designed and constructed. These studies led to the calculation of the amount of thrust produced by the device and, in turn, power produced and efficiencies. Even though the device was inefficient (0.09%), and thrust produced by the device was minuscule (42.8 mN, 0.015 IB), the efficiency proved to be 53 times greater than the xenon ion propulsion system [XIPS] used by NASA today. This research confirmed a test method and uncovered information about devices that may prove to be a novel form of propulsion in years to come.

Alteration of fabric strength and texture by exposure to elevated concentrations of ozone. ANGY MOUNIR, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

Ozone, a strong oxidant, is known to reduce the strength of rubber and some fabrics. There has been limited research on ozone's effect on common fabrics, the focus of this project. The purpose was to determine how physical characteristics of various textiles are affected by exposure to the oxidant. These studies included four widely used fabrics: cotton, polyester, rayon, and spandex. The fabrics were exposed to 49 ppm ozone for 40 hours, and cotton and polyester were exposed for an additional 30 hours since they showed no effects after the original interval. A dissecting pin attached to a computer force probe enabled the measurement of the force needed to induce failure in control and experimental textiles. Ten trials took place for each sample. The average values for the control fabrics were 2.17 N for cotton, 8.01 N for polyester, 3.38 N for rayon, and 1.19 N for spandex. After the initial ozone exposure, rayon had deteriorated, so that the average force to puncture was only 2.20 N. Cotton showed no significant change after 40 hours (2.29 N). However, it weakened after 70 hours so that only 1.88 N were required to puncture it. Polyester also did not change in strength after 40 hours (9.24 N) or 70 hours (8.09 N). Using NIH Image software, microscopic examinations of both the control and exposed fabrics were con-

ducted. Cotton and polyester displayed no changes in microscopic profile after exposure. Rayon's light regions after exposure were slightly smaller than before ($P = 0.03$), and dark regions after exposure were substantially longer than before ($P < 0.001$). Spandex's dark areas appeared smaller, and the white areas more frayed. There was no change in appearance after exposure in any fabric, except spandex, which yellowed.

ZOOLOGY

Preference of cave and surface crayfish for dispersion and directionality in a moving stream. ANN SIMONE COOPER, Morton Middle School, 1225 Tates Creek Road, Lexington, KY 40502.

During observations in Sloan's Valley cave (Somerset, Kentucky), I noticed that blind cave crayfish were present in pools of water that were isolated from the bigger pools of water connected to surface rivers and lakes. It was hypothesized that cave crayfish are driven to go upstream when the opportunity arose during rains or snow melt. A second hypothesis, that when crayfish are in a group within a small pool they will seek out new places faster than if by themselves, was also tested. Artificial streams and pools were constructed in my basement to test these hypotheses. The cave crayfish, *Orconectes australis packardi*, and a surface species, *O. cristavarius*, were utilized. Animals of both species were marked for individual identification. Animals were placed as individuals or in groups in a middle pool and monitored for movement upstream or downstream over time. The results indicate that cave crayfish ($n = 11$) as individuals prefer to go downstream as compared to surface crayfish ($n = 9$) (up:down; cave-3:6 and 2 stayed in the middle tank, surface-6:3). When either species is in a group ($n = 9$ cave, $n = 8$ surface) within a small pool they seek out new places faster than if by

themselves at twice the rate (individual:group, cave-986:405, surface-2492:1001 minutes). The faster movements as a group held for both species; however, the cave crayfish chose to move upstream or downstream sooner than surface crayfish as individuals as well as in a group.

A study of symmetry-related behaviors in the bug *Oncopeltus fasciatus*. ALISHA RUST, Notre Dame Academy, 1699 Hilton Drive, Covington, KY 41011.

The large milkweed bug, *Oncopeltus fasciatus*, is a ground-dwelling insect that undergoes incomplete metamorphosis. A culture of *O. fasciatus* was obtained from Carolina Biological and maintained in a small aquarium. Eggs, nymphs in all five instars, and adults were included in the culture. As a member of the order Hemiptera, *O. fasciatus* possesses two wings that are folded on the dorsal thorax. Preferences in wing folding as well as foreleg departure were of interest, and therefore became an object of study. Wing folds were observed after the insect repositioned its wings after flight. All of the insects but one folded right wings over left in all ten of the trials, suggesting that a genetic predisposition for right wing preference might be possible. In addition, all of the insects displayed a preference for initiating movement with the right foreleg. The adult milkweed bug is colored orange and black with a specific, symmetrical color pattern. Matting in milkweed bugs takes place over an extended period of time and is easily observed. Symmetry as a factor in female mate selection was investigated. A female was placed with an asymmetrical male, whose right dorsal side had been painted black, and a symmetrical male. Matings and prenuptial interactions between males and females were observed. It was found that females had no preference for either symmetrical or asymmetrical males. These data differ from findings of other investigators using species of grasshoppers and scorpionflies.

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John W. Thieret

Department of Biological Sciences

Northern Kentucky University

Highland Heights, KY 41099

Phone: (859) 572-6390; Fax: (859) 635-3490

E-mail: thieretj@exchange.nku.edu

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